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SCHOOL OF CELTIC STUDIES

1 Research Work

Annual report of the Governing Board of the School of Celtic Studies for the year ending 31 December 2008 adopted at its meeting of 11 June 2009.

Foireann agus Scoláirí/Staff and Scholars

Senior Professors: Liam Breatnach, Pádraig A. Breatnach, Fergus Kelly (Director) Professors: Malachy McKenna, Pádraig Ó Macháin

Assistant Professors: Aoibheann Nic Dhonnchadha, Michelle O Riordan (Publications Officer)

Bibliographer: Alexandre Guilarte

Dialectologist: Brian Ó Curnáin

Bergin Fellows: Clodagh Downey, Roisin McLaughlin

O'Donovan Scholars: Brent Miles (to 1 October), Nora White, Gordon Ó Riain, Freya Verstraten Veach, Eoin O'Flynn (from 1 October)

Librarian: Margaret Kelly

Library Assistant: Órla Ní Chanainn

School Administrator: Eibhlín Nic Dhonncha

Technical Staff : ISOS: Anne Marie O'Brien (replaced by John O'Brien while on maternity leave)

IT support: Andrew McCarthy (part-time), Stephen McCullagh (part-time)

1.1 Taighde/Research

Dialect Studies

Brian Ó Curnáin continued his work on the Irish of Galway, and carried out field-work in recording various Irish speakers from Turlach Beag, Ros Muc, from Gairfean, Ros Muc, from Cladach ó dheas, Ros Muc, from Camas, and from Béal Átha na mBreac, An Mám. He also made progress with his monograph on the Irish of An Caisleán Gearr and Baile Chláir. He maintained communication with Séamas Ó Direáin regarding his work on *A survey of spoken Irish in the Aran Islands, Co. Galway* which is being prepared for submission to the School of Celtic Studies. He wrote on various aspects of phonetics and grammar. He continued his research in Irish dialectology, Gàidhlig, general linguistics, and syntax.

He also transcribed recordings of young children from Ros Muc. He attended the International Sociolinguistics conference in Amsterdam. He also attended a conference on the work of Acadamh na hOllscolaíochta in Carna, Co. Galway, as well as various lectures on Irish sociolinguistics and on minority languages hosted by the National University of Ireland, Galway. Malachy McKenna continued his work on *The Irish of Rann na Feirste: a phonemic study*, and made regular field-trips to Rann na Feirste in connection with this monograph.

Textual editions, etc.

Liam Breatnach continued work on his edition of the Old Irish law-tract *Córus Bésgnai*, as well as collecting material for his projected *Grammar of Middle Irish*.

Pádraig A. Breatnach continued work on 'Chronicle poems of the Nine Years' War' (Dubhthach Ó Duibhgeannáin). He worked on the Irish apocryphal texts ('Airdena inna cóic la ndéc ria mbráth', 'Airecc na nApstal'). His study visits in 2008 included Munich University and Bayerische Staatsbibliothek (28-30 April) and the British Library, London (2-5 September).

Clodagh Downey continued her research on the poetic corpus of the Middle Irish poet, Cúán ua Lothcháin. This involved consultation and transcription of many manuscripts containing this poetry, edition and collation of these transcriptions, translation and annotation of the texts and study of the life and background of the poet.

Fergus Kelly prepared additional material for a revised edition of *Bechbretha*. He started on an edition of an Old Irish text on legal disputes within marriage (*Corpus Iuris Hibernici* 144.5-150.16). He also continued his work on an edition of the Legal Treatise by Giolla na Naomh Mac Aodhagáin (*Corpus Iuris Hibernici* 691.1-699.4)

Roisin McLaughlin finalised her book *Early Irish Satire*, which was launched at the Institute on 2 October. She also continued work on editions of *Mittelirische Verslehren III* and *In Lebor Ollaman*. She started an edition of the homily on fasting *Cétaín in Braith in Leabhar Breac* (Royal Irish Academy MS 23 P 16, f. 44).

Gerald Manning (Post-doctoral IRCHSS Fellow) continued work on the preparation of a critical edition of the Old Irish law-text *Uraicecht Becc*.

SCHOOL OF CELTIC STUDIES

Gordon Ó Riain was awarded a doctorate from the National University of Ireland for his critical edition of four poems by the fifteenth-century poet Maol Eachlainn 'na nUirsgeal' Ó hUiginn. He prepared an edition of the poem beginning *Ionmhain taise a-tá i nDoire* for publication in 2009.

Nora White continued work on her edition of the rule of Mo Chutu. She completed work on the *Monasticon Hibernicum* database project, which will go up on the School's website in 2009.

Historical studies

Michelle O Riordan continued her research work on 17th century political poetry; and research on political imagery in 16th –17th century works on Ireland for the Arlen Press Pamphlets series.

Freya Verstraten Veach completed her PhD thesis 'The Anglicisation of the Gaelic nobility c.1169 – c. 1366'; the degree was conferred in June.

Eoin O'Flynn is in the second year of research towards the degree of PhD. His general area of interest is the political history of the Irish midlands. More specifically, his current research is focused on the early history of the Clann Cholmáin dynasty.

Cataloguing of manuscripts

1.2 Tionscnamh Leabhar Breac/Leabhar Breac Project

Professor Liam Breatnach continued with the team project which will provide a diplomatic edition of the *Leabhar Breac*, in both printed and digitised form. The team currently consists of Clodagh Downey, Roisin McLaughlin, Nora White, and Gordon Ó Riain.

1.3 Meamram Paipéar Ríomhaire/Irish Script on Screen (ISOS)

The Irish Script on Screen project (ISOS) continues under the direction of Professor Pádraig Ó Macháin. 2008 represented the busiest year to date for the ISOS website. In excess of 2,200,000 visits to the site were registered for the year. Digitisation of Irish manuscripts continued at the Royal Irish Academy in January and in the months of June, July and August.

Following lengthy discussions with the owners, one of the most important Irish manuscripts still remaining in private ownership was digitised by ISOS this year. The Book of the O'Conor Don, written in Ostende in 1631, is an important collection of bardic verse. Its digitisation by ISOS marks an important development in the accessibility of Ireland's manuscript materials.

On 2 February, ISOS organised and hosted another in its series of seminars at the DIAS. The seminar, entitled 'The Virtual Library of Switzerland', was conducted by Dr Christoph Flüeler, Professor of Manuscripts and Medieval Latin at the University of Fribourg. Professor Flüeler came to Dublin at the invitation of ISOS to speak about two digital projects in which he is involved in Switzerland: the *Codices Electronici Sangallenses*, and the E-Codici project, both of which are similar to ISOS.

The attendance of fifty at this seminar was drawn from archival and academic bodies throughout the country, representing a wide range of medieval, palaeographical, and scientific interests. All the main national repositories sent representatives, as did a number of county libraries. The ensuing discussions and exchange of ideas proved stimulating, and all were in agreement as to the excellence of Professor Flüeler's presentation, and of the informative and productive nature of the ISOS seminars.

Arising from contacts established by ISOS, Professor Ó Macháin travelled to Québec City in April to acquire for the State a nineteenth-century Irish manuscript that had come to light in private possession. In addition to dealing with the usual information and publication requests from the public, ISOS digitised a fifteenth-century Old Icelandic medical manuscript (RIA 23 D 43) at the request of the National Library of Iceland.

1.4 Tionscnamh Bibleagrafaíochta/Bibliography Project

Alexandre Guilarte continued the compilation of the fourth volume of the "Bibliography of Irish Linguistics and Literature", focusing on the cataloguing and analysis of core periodical publications in the field of Irish studies. A permanently updated web-based version of BILL IV has been made available to all staff and scholars at DIAS, while the version offered to the general and academic public is being updated on a weekly basis.

1.5 Eagarthóireacht/Editing

Liam Breatnach: Co-editor (with Rolf Baumgarten and Damian McManus) *Ériu*, volume 58. published by the Royal Irish Academy in December.

Pádraig A. Breatnach: Editor of *Éigse: A Journal of Irish Studies*, volume 36.

Fergus Kelly: Co-editor of *Celtica* 26.

Malachy McKenna: Co-editor of *Celtica* 26.

Aoibheann Nic Dhonnchadha: Comh-eagarthóir, *An Linn Bhuí: Iris Ghaeltacht na nDéise*, imleabhar 12.

Michelle O Riordan: Arranged for the printing of School of Celtic Studies publications.

Pádraig Ó Macháin: Edited and contributed introduction to the second edition of *Ghaibh a leithéid an tslí tráth* by Pádraig Ó Fiannúsa (Waterford 2008). Comh-eagarthóir, *An Linn Bhuí: Iris Ghaeltacht na nDéise*, imleabhar 12. Editor *Ossory, Laois and Leinster*, Volume 3.

1.6 Foilsitheoireacht/Publishing

As one of its statutory functions, in addition to research and publication by its own staff, the School provides for the assessment, editing, and publishing of books and papers by outside scholars. The following books were published in 2008:

Roisin McLaughlin, *Early Irish Satire* ISBN 978-1-85500-207-4.

Kim McCone, *The Celtic Question: Modern Constructs and Ancient Realities* ISBN 978-1-85500-210-4

Reprints

The following reprints were seen through the press by the School's Publications Officer, Michelle O Riordan:

T. F. O'Rahilly, (ed.) *Celtica 1 part 1* (ISBN 1-85500-014-8)

Myles Dillon (ed.) *Celtica 3* (ISBN 1-85500-047-4)

Seán de Búrca, *The Irish of Tourmakeady, Co. Mayo: a phonemic study* (ISBN 0-90128-249-9)

R. I. Best, Osborn Bergin and M. A. O'Brien (ed.), *The Book of Leinster vol. 1* (ISBN 1-85500-037-7)

P.-Y. Lambert (ed.), *Lexique étymologique de l'irlandais ancien de J. Vendryes: lettre D* (ISBN 2-271- 05415-X).

T. F. O'Rahilly, Kathleen Mulchrone et al., *Catalogue of the Irish manuscripts in the Royal Irish Academy*, vols 2, 3, 6 and 8.

T. M. Charles-Edwards and F. Kelly (ed.) *Bechbretha: an Old Irish law-tract on bee-keeping* (ISBN 978-1-85500-209-8).

1.7 Díolachán Leabhar/Sale of Books

Promotion of publications was effected by the School Administrator, Eibhlín Nic Dhonncha, through advertising in national and international newspapers, *Books Ireland*, *National Concert Hall Annual Brochure*, *Comhar*, *Saol*, *Foinse*, *Lá*, *Conradh na Gaeilge: Clár Seachtain na Gaeilge*, *An tOireachtas: Clár na Féile*, *Lámhleabhar An Choláiste Ollscoile Baile Átha Cliath*, *Library News*.

1.8 Foilseacháin/Publications

Liam Breatnach: 'Cinnus atá do thinnrem, a poem to Máel Brigte on his coming of age', *Ériu* 58 (2008) 1-35. Review of Kevin Murray, *Baile in Scáil. The Phantom's Frenzy* (London 2004). *Irish Texts Society* volume 58, in *Cambrian Medieval Celtic Studies* 55 (2008) 75-82.

Pádraig A. Breatnach: 'Scribhinní i láimh Eoghain Ruaidh Mhic an Bhaire', *Éigse* 36 (2008) 43-62 (with plate). 'Changed loyalties in Thomond', *Éigse* 36 (2008) 132-37. 'Varia. 1. Attack on an ignorant scholar'; 2. 'Truagh do chor a chroidhe tim (Eoghan Ruadh Mac an Bhaire) q. 17'; 3. 'Díoth ollaimh easbhuidh Laighean (*Éigse* 27, 101-14)', *Éigse* 36 (2008) 138-44.

Clodagh Downey: 'The life and work of Cúán ua Lothcháin', *Ríocht na Midhe* 19 (2008) 55-78. 'Women, the world and three wise men: power and authority in tales relating to Níall Nóigiallach and Lugaid mac Con', in Dan M. Wiley (ed.) *Essays on the Early Irish King-tales* (Dublin, 2008) 127-47. 'Purple Reign: the naming of Conall Corc' in Katja Ritari and Alexandra Bergholm (eds) *Approaches to Religion and Mythology in Celtic Studies* (Newcastle, 2008) 27-53. 'Trí croind Éirenn oiregdha: a medieval poem on three famous trees in Ireland', *Éigse* 36 (2008) 1-34.

Fergus Kelly: Additional Appendix in revised edition of *Bechbretha* (ed. Thomas Charles-Edwards and Fergus Kelly 1983; reprinted 2008). 'Drifting on the ocean: are Old Irish *cnoe gnáe* "beautiful nuts" to be identified as sea beans?' (for a forthcoming Festschrift). Review of Sara Elin Roberts, *The Legal Triads of medieval Wales* (for *Cambrian Medieval Welsh Studies*), forthcoming.

Roisín McLaughlin: *Early Irish Satire*.

Michelle O Riordan: *Palgrave History of Ireland, chapter 2: 600-1800, New Approaches*, (2009).

'Dána an turas trialltar sonn' – páirt de scéalaibh agus d'imtheachtaibh Uí Néill nuair a d'fhág sé Éire', in *Éire agus an Eoraip sa 17ú haois: Léachtaí Cholm Cille XXXVIII*, lgh. 39-99, Má Nuad, 2008.

Aoibheann Nic Dhonnchadha: 'The "Book of the O'Lees" and other medical manuscripts and astronomical tracts', in *The Royal Irish Academy Library Treasures* ed. Siobhán Fitzpatrick (forthcoming)

Brian Ó Curnáin: 'Canúineolaíocht', alt don *Lámhleabhar Sochtheangeolaíochta* (curtha in eagar ag Tadhg Ó hIfeárnáin agus Máire Ní Neachtain).

Gordon Ó Riain: 'Early modern technical verse from NLI G 3', *Éigse* 36 (2008) 35-42. 'The consonant cluster – *rdh*', *Éigse* 36 (2008) 82-6. 'Some identifications of citations in the grammatical tracts', *Éigse* 36 (2008) 215-16.

Pádraig Ó Macháin: 'The flight of the poets: Eóghan Ruadh and Fearghal Óg Mac an Bhaire in exile', *Seanchas Ard Mhacha* 21-22 (2007-2008) 39-58. 'The hand of Conall Ó Mórdha', *Ossory, Laois and Leinster* 3 (2008) 54-72. 'Léiriú anaman agus altóra: teagasc an Athar de Bhál 2', *An Linn Bhuí* 12 (2008) 178-203.

Nora White: *The Monasticon Hibernicum* database for the School of Celtic Studies website (forthcoming).

Freya Verstraten Veach: 'The Uí Fhearghail lordship of Anghaile', a contribution to *Longford History and Society*, eds Fergus O'Ferrall and Martin Morris (forthcoming 2009).

1.9 Leabharlann/Library

A new library security system was installed in February. The library reception area was refurbished to house the new system. All books were tagged with security strips and the system went into operation in July. The circulation function was added to the library management system and self issue was set up. All staff members were issued with a library card. Training on self issue was carried out during the summer and self issue of library books is now automated. These additions to the library management system will add to the security of the collection.

Current and retrospective cataloguing continued. Acquisitions continued in subject areas relevant to the research needs of the School. Regular updates on recent accessions and current periodicals were issued and research and bibliographical queries from members of the School were dealt with.

Interlibrary loans were ordered, consulted and returned to the lending institution. The donated book collection of the late Professor Proinsias Mac Cana was moved to the School and work began on housing these items which will be made available as a reference library for scholars and staff of the School. A record number of visitors to the library was recorded during the Summer School in July 2008. Reading list items were put on reserve at the library desk and staff were on hand to answer queries. Gretchen de Búrca worked on the retrospective cataloguing project during the summer and also worked at the issue desk.

Margaret Kelly attended two seminars organised by groups within the Library Association of Ireland. The first seminar hosted by the Rare Books Group was entitled: *Identifying Historical Bindings* which was held in the Russell Library, National University of Ireland, Maynooth, in June. Margaret also attended a seminar hosted by the Cataloguing and Indexing Group on the subject of *Sourcing MARC Records* held in November 2008 at the National Library of Ireland. Órla Ní Chanainn attended a *Heritage Data Management* course in June 2008 at the Trinity Capital Hotel, Dublin.

1.10 Imeachtaí/Events

Statutory Public Lecture

This year's Statutory Public Lecture was delivered by Professor Pádraig A. Breatnach, School of Celtic Studies. The title of the lecture was 'The Four Masters and their works: a team enterprise'. It was delivered as part of the Tionól in the National University of Ireland, Belfield, Dublin, on Friday 28 November to an audience of approximately ninety.

Other Lectures

On 24 April Professor Kim McCone (NUI Maynooth) gave the Third Myles Dillon Memorial Lecture entitled 'The Celtic Question: Modern Constructs and Ancient Realities'. On 24 May a one-day Conference on 'Ogam in 3D' was jointly hosted by the School of Celtic Studies and the School of Theoretical Physics. Lectures at this Conference were given by Werner Nahm (School of Theoretical Physics, DIAS), Alexandre Tokovinine (Harvard University), Colin Muir (Historic Scotland's Conservation Centre, Edinburgh), Annemarie La Pensée (National Museums Liverpool), Dáibhí Ó Cróinín and Thierry Daubos (National University of Ireland, Galway), Fionnbarr Moore (National Monuments Service, Department of the Environment, Dublin), Fergus Kelly, School of Celtic Studies, DIAS).

Tionól 2008

The School's annual Tionól took place on 28 and 29 November 2008, organised by Professor Pádraig Ó Machain with assistance from Eibhlín Nic Dhonncha. It attracted the largest attendance to date, with numbers exceeding one hundred on both days.

Papers on various aspects of Celtic Studies were delivered by twenty speakers. The speakers came from Germany, the Netherlands, Finland, United States of America, Wales, England, and Ireland.

The following is the list of speakers and papers:

Peter McQuillan (University of Notre Dame, Indiana) 'Civil Conversation' and literature in Irish in the seventeenth century'

Gwen Awbery (University of Wales, Cardiff) 'Welsh place-names and the interaction of syntax and semantics'

Gordon Ó Riain (School of Celtic Studies, DIAS) 'A fifteenth-century apologue on the death of Cú Chulainn'

Matthias Egeler (University of Oxford, England) 'Some considerations on the Celtic character of the *Lamia tres* of the dedication stone CIL VII, 507 from the Roman fort Condercum on Hadrian's Wall'

Nicholas Zair (University of Oxford, England) Middle Welsh subjunctive 1sg. -oef, 3sg. -oe: an Insular Celtic 'ā-subjunctive'?

Graham Isaac (NUI, Galway) 'The wave mechanics of Early Welsh verse'.

Esther Le Mair (NUI, Galway) 'Some verbs in the Würzburg Glosses'.

Nicholas Williams (NUI, Belfield, Dublin) 'The Brythonic preterite and Cornish syntax'.

Immo Warntjes (University of Greifswald, Germany) 'The oldest occurrence of Old English *gerīm*'.

Markku Filppula and Juhani Klemola (University of Joensuu, Finland) 'Celtic influences in English: a re-evaluation'.

Cathy Swift (University of Limerick) 'Sex in the civitas: early Irish intellectuals and their vision of women'.

Tadhg Ó Dúshláine (NUI, Maynooth) '*Cuir srian rem chorp a Choimthe: foinse agus fáth airge*'.

Brian Ó Dálaigh (Dublin) 'The Í Mhaoil Chonaire of Thomond'.

Máire Ní Mhaonaigh (University of Cambridge, England) 'A fragmentary account of "Brian's battle" in Rawlinson B 486'.

Fiona Edmonds (University of Cambridge, England) 'Gaelic personal names in medieval northern England'.

Johan Corthals (University of Hamburg, Germany) 'The *Áiliu* poems in *Bretha Nemed Dédenach*'.

Clodagh Downey (School of Celtic Studies, DIAS) 'Dindshenchas and the Tech Midchuarta'.

SCHOOL OF CELTIC STUDIES

Pádraig Moran (University of Cambridge, England) 'Hebrew in Irish glossaries'.

Freya Verstraten Veach (School of Celtic Studies, DIAS) 'Was Walter de Burgh (†1271), Earl of Ulster, a descendant of Cathal Croibhdhearg Ó Conchobhair?'

Fergus Kelly (School of Celtic Studies, DIAS) 'Distrain of bees: a recently discovered Middle Irish legal commentary'.

Seminars

Liam Breatnach completed his series of weekly seminars on the text edited by Kuno Meyer in ZCP 7 (1910) 304-5, under the title 'Bestrafter Pferdediebstahl' (April-May). He also conducted a seminar on the Old Irish law-text *Críth Gablach*.

Pádraig A. Breatnach continued a weekly seminar on 'Poems on the O'Donnells (1200-1600)' (January-February).

Fergus Kelly held a weekly seminar on 'An Old Irish law-text on disputes within marriage' (October-December).

Roisín McLaughlin completed her weekly seminar on the Middle Irish Metrical Tract *Mittelirische Verslehren III* (January-February).

Roy Flechner (visitor from Trinity College Cambridge) gave two seminars in March on his edition of the *Collectio Canonum Hibernensis*, which he intends to submit to the Early Irish Law Series.

1.11 Léachtaí (Foireann agus Scoláirí)/ Lectures (Staff and Scholars)

Liam Breatnach: 'The king in the Old Irish law texts' The 10th symposium of *Societas Celtologica Nordica*, Gothenburg, Sweden (17-19 July). A complete course of Advanced Old Irish (12 sessions) and the second half of the course on Early Irish Law and Society, and the Learned Orders (6 sessions) at the School of Celtic Studies Summer School in Mediaeval and Modern Irish Language and Literature held from the 14th – 26th July 2008.

Pádraig A. Breatnach: Advanced Modern Irish Course, Summer School, SCS; 'Metre and Poetry in the Modern Irish Accentual Tradition I-III' (Summer School, SCS). 'Scoláireacht na Nua-Ghaeilge sa chóras Ard-Oideachais' Coláiste Phádraig, Droim Conrach, Baile Átha Cliath (5

Samhain). 'The Four Masters and their works: a team enterprise' NUI, Belfield, Dublin, (November). 'Cupid, the Suitor and the Harlot': Keynote address at Symposium on Bardic Poetry, University of Princeton (December). 'Metre and poetry in the Modern Irish accentual tradition' School of Celtic Studies Summer School, Dublin (July).

Clodagh Downey: 'Ailill Molt, rí Chonnacht', Comhdháil ar Chultúr agus Litríocht na Gaeilge, Ollscoil na hÉireann, Gaillimh (18 Deireadh Fómhair). 'Dindshenchas and the Tech Midchúarta', Tionól, School of Celtic Studies, Dublin Institute for Advanced Studies (29 November) 'Dindshenchas and the Tech Midchúarta', Department of Early and Medieval Irish, NUI, Cork (10 December). A complete Elementary Old Irish course (12 sessions) at the School of Celtic Studies, Summer School in Medieval and Irish Language and Literature (14 – 21 July), as well as three lectures on literature.

Fergus Kelly: 'The early Irish law of evidence' (*Societas Celtologica Nordica*, Gothenburg, Sweden, (17 June). Six lectures on 'Early Irish law and society', School of Celtic Studies Summer School (July). 'Distrain of bees: a recently discovered Middle Irish legal commentary' School of Celtic Studies Tionól (November)

Malachy McKenna: A complete course of Elementary Modern Irish (12 sessions) at the School of Celtic Studies Summer School (July), and prepared a course-book for the use of the Summer School students.

Roisín McLaughlin: 'Féníus Farsaid and the Alphabets', Thirtieth Annual University of California Celtic Studies Conference (March). 'Types of Satire in Early Ireland', Celtic Studies Association of North America, Colgate University, New York. Two lectures at the School of Celtic Studies Summer School (July).

Aoibheann Nic Dhonnchadha: 'The Medical texts in Harley 546: a discussion of their sources'. Paper read at British Library Symposium: 'Healing and the Harley Collection: Medieval Medical Manuscripts revealed', Warburg Institute, London (July). 'Lámhscríbhinní leighis na Gaeilge, 1400-1650': léacht tugtha ag Daonscoil na Mumhan in Coláiste na Rinne, Rinn Ó gCuanach, Co. Phort Láirge (Lúnasa). Two lectures at the School of Celtic Studies Summer School (July).

Brian Ó Curnáin: 'Mionlú na Gaeilge', Léachtaí Cholm Cille, Coláiste na hOllscoile, Má Nuad, Co. Chille Dara.

Pádraig Ó Macháin: Two lectures on Irish Manuscripts at the School of Celtic Studies Summer School (July). 'The survival of Bardic Poetry', Princeton University (December).

Gordon Ó Riain: 'A fifteenth-century apologue on the death of Cú Chulainn'. School of Celtic Studies Tionól (November).

Freya Verstraten Veach: 'Was Walter de Burgh (†1217), Earl of Ulster, a descendant of Cathal Croibhdhearg Ó Conchobhair?', School of Celtic Studies Tionól (November).

Nora White: 'The Rule of Mo Chutu', Trinity College Early Irish Society lecture series (November).

1.12 Cúrsaí in Ollscoileanna Éireannacha/ Courses in Irish Universities

Brian Ó Curnáin: léachtaí in Acadamh na hOllscolaíochta Gaeilge, Ollscoil na hÉireann, An Cheathrú Rua, Co. na Gaillimhe, don Chúrsa MA sa Phleanáil Teanga.

Michelle O Riordan: 'A Survey of Irish Literature' for the Irish Studies Module, First-year Bachelor in Arts and Theology (BARS), Mater Dei Institute of Education, Dublin City University.

Malachy McKenna: dhá chúrsa i Scoil na Gaeilge, Coláiste na Tríonóide, Baile Átha Cliath: 'Bunfhoghraíocht na Nua-Gaeilge' agus 'Gaeilge Uladh'.

1.13 Scrúdaitheoireacht Sheachtrach/ External Examining etc.

Liam Breatnach: external examiner for Early and Medieval Irish, National University of Ireland, Maynooth.

Fergus Kelly: external examiner for a PhD thesis (viva 29 July, Department of Celtic and Scottish Studies, University of Edinburgh).

Michelle O Riordan: external examiner for first year BARS students in DCU (Mater Dei Institute).

1.14 Na Meáin Chumarsáide agus Aithne Phoiblí/Media and Public Awareness

Website of the School of Celtic Studies

New content was added to the School of Celtic Studies website (www.celt.dias.ie) on a continuing basis under the direction of Professor Pádraig Ó Macháin and Andrew McCarthy. Queries from outside scholars, students and the general public were dealt with.

Television and radio

Pádraig Ó Macháin did various radio interviews on KCLR and on Midlands 103.

Aoibheann Nic Dhonnchadha participated (at the request of CELT, UCC) as interviewee in an article entitled 'Putting medical history online', by Eoin Burke-Kennedy, in Health Supplement, *Irish Times* (September).

1.15 Coistí/Committees

Liam Breatnach: Chairman of the organising committee of the Summer School in Mediaeval and Modern Irish Language and Literature held from the 14th–26th July 2008.

He worked as Local President of the Organising Committee of the XIV International Congress of Celtic Studies to be held in Maynooth, 1st – 5th August, 2011.

Pádraig A. Breatnach: Ball de Choiste Náisiúnta Léann na Gaeilge, Acadamh Ríoga na hÉireann. Member of Comité International de Paléographie Latine, XVIth Colloquium 'teaching Writing, Learning to Write', University of London. Member of the Irish New Testament Apocrypha Project (Editing Committee). Chairman, Publications Committee of the School of Celtic Studies.

Fergus Kelly: Member of advisory panel of eDIL (Supplement to the *Dictionary of the Irish Language*) University of Ulster, Coleraine, 2 April; University of Ulster, Belfast, 14 November.

Michelle O Riordan: Member of Ralahine Utopian Studies Seminar.

The Librarian Margaret Kelly was appointed to the committee of the Academic and Special Libraries Section of the Library Association of Ireland www.libraryassociation.ie. She is also a member of the working group for Library Ireland Week 2008.

Aoibheann Nic Dhonnchadha: Ball de Choiste Náisiúnta Léann na Gaeilge, Acadamh Ríoga na hÉireann.

SCHOOL OF CELTIC STUDIES

1.16 Bord Rialúcháin Scoil an Léinn Cheiltigh/Governing Board of the School of Celtic Studies

Professor Anders Ahlqvist (Chairman)
Professor Angela Bourke
Professor Máire Herbert
Professor Liam Mac Mathúna
Dr Eilís Ní Dheá
Professor Dónall Ó Baoill
Dr Nollaig Ó Muraíle
Professor Ruairí Ó hUiginn
Dr Katharine Simms
Professor Liam Breatnach
Professor Fergus Kelly
Professor Pádraig A. Breatnach

The Governing Board of the School of Celtic Studies met four times in 2008: 28th February, 14th May, 2nd October and 27th November.

1.17 Cuairteoirí agus Comhaltaí/Visitors and Associates

Visiting Professors

Professor Markku Filppula (University of Joensuu, Finland)
Professor Tomás Ó Cathasaigh (Harvard University, USA)
Professor Thomas Charles-Edwards (Jesus College, Oxford, UK)
Professor Johan Corthals (University of Hamburg, Germany)
Professor Peter Schrijver (University of Utrecht)
Professor Pádraig Ó Néill (The University of North Carolina at Chapel Hill)

Visiting IRCHSS Research Fellow

Dr Caoimhín Breatnach (University College Dublin)

Research Associates

Dr Gwenllian Awbery, University of Wales, Cardiff (1990)
Dr John Carey, National University of Ireland, Cork (1990)
Professor Thomas Charles-Edwards, University of Oxford (1990)
Professor Toshio Doi, Nagoya Women's University, Japan (1991)

Professor David N. Dumville, University of Aberdeen (1989)
Professor D. Ellis Evans, University of Oxford (1990)
Professor William Gillies, University of Edinburgh (1989)
Professor Geraint Gruffydd, Centre for Advanced Welsh and Celtic Studies, Aberystwyth (1989)
Professor Eric P. Hamp, University of Chicago (1989)
Dr Anthony Harvey, Royal Irish Academy (2004)
Professor Donald MacAulay, University of Glasgow (1989)
Professor James McCloskey, University of California, Santa Cruz (2004)
Dr Martin McNamara, MSC, Milltown Institute of Theology and Philosophy (1989)
Professor Toshitsugu Matsuoka, Hosei University, Tokyo (1991)
An tOllamh Donnchadh Ó Corráin, Coláiste na hOllscoile, Corcaigh (1991)
An tOllamh Ruairí Ó hUiginn, Ollscoil na hÉireann, Má Nuad (1999)
Dr Tom O'Loughlin, University of Wales, Lampeter (2003)
Professor Pádraig Ó Néill, The University of North Carolina at Chapel Hill (1990)
Dr Morfydd Owen, Bryn Eithin, Aberystwyth (2003)
Dr Brynley F. Roberts, National Library of Wales, Aberystwyth (1990)
Professor R. Mark Scowcroft, Catholic University of America (1990)
Professor Richard Sharpe, University of Oxford (1988)
Professor Calvert Watkins, Harvard University (1990)

Visiting Scholars

Overseas scholars (apart from those listed above under Visiting Professors) who availed of library and research facilities are included in the following list. In addition to these, the School accords library and research facilities to Irish-based scholars when it holds materials which are lacking in the scholars' own institutions and in the major libraries in Dublin.

Jacqueline Borsje (University of Amsterdam, The Netherlands)
Aidan Breen (University of Massachusetts, Boston, USA)

Father Chrysostom Stavrakis (Aristotle University of Thessalonica, Greece)

Riitta Latvio, (University of Helsinki, Finland)

Melita Cataldi (University of Torino, Italy)

Piero de Gennaro, (University of Torino, Italy)

Joseph F. Eska (Virginia Tech, Virginia, USA)

Roy Flechner, (Trinity College, Cambridge, England)

Margo Griffin-Wilson (Harvard University, USA)

Breandán Ó Buachalla (University of Notre Dame, Indiana, USA)

Jan Erik Rekdal (University of Oslo, Norway)

Cornel Peter Rodenbusch (Tübingen University, Germany)

Mark Scowcroft (Catholic University of America, Washington D.C., USA)

SCHOOL OF COSMIC PHYSICS

ASTRONOMY AND ASTROPHYSICS

1 Highlights

In 2008 the combined Astronomy and Astrophysics Section has:

- published 52 refereed publications with a further 22 preprints submitted and three volumes of conference proceedings being edited;
- made the front cover of Astronomy and Astrophysics twice;
- had the review article High energy astrophysics with ground-based gamma ray detectors by F Aharonian, J Buckley, T Kifune and G Sinnis listed as one of the 10 highlights of 2008 by the editors of Reports on Progress in Physics;
- organised a school, a workshop and a major international conference;
- submitted and successfully defended four PhD and one MSc theses;
- overseen the introduction of the BlueGene-based national capability computing service;
- facilitated through e-INIS a major upgrade of the national capacity service and commenced planning of the e-INIS national data service;
- increased the number of brown dwarfs with detected outflows to 5 (this was the subject of a press release at the Belfast meeting of the RAS);
- through the HESS collaboration detected TeV emission from the remnant of SN1006 and also from the radio galaxy Cen A;
- proposed a quantitative numerical MHD model for the M87 jet which is in good agreement with the observations;
- implemented the JETset database;
- continued to expand the programme of events and open nights in Dunsink within resource limitations – the total number of visitors is now approaching 2000 per year.

2 Staff

Senior Professors Luke Drury, Evert Meurs

Professors Felix Aharonian, Tom Ray

Emeritus Professors Denis O'Sullivan, Alex Thompson, Ian Elliott, Tao Kiang

Honorary Professor of Computational Science Jean-Christophe Desplat, Associate Director of ICHEC

Schroedinger Fellows Andy Lim, Carlos del Burgo, Masha Chernyakova

EU Marie Curie Fellow Stefano Gabici

IRCSET Fellows Deirdre Coffey (from 1st Nov), Paul Dempsey, Linda Podio

SFI-funded Researchers Rachel Curran (to 31st Jan)

Visiting Scientists Mark Dieckmann (Norkoping University, Sweden), Turlough Downes (on secondment from DCU)

Hamilton Scholars Sean Delaney, Jonathan Mackey, Denys Malyshev, Elisa Nichelli (to 3rd Apr), Lisa Fallon (from 1st Sep), Laure Barreyre (from 1st Oct), Nakisa Nooraee (from 17th Nov)

Experimental Officer (IT support unit)
Stephane Dudzinski

Senior Technical Officer (Dunsink Observatory)
Mike Smyth

Technical Officers Anne Grace, Hilary O'Donnell, Eileen Flood

Secretarial and Reception Phyllis Daly, two vacancies

IT support Phillipe Grange

Groundsmen (Dunsink Observatory) Thomás Mac Grioffa, Bartłomiej Migas

e-INIS project coordinator and outreach officer Keith Rochford (from 16th June)

JETSET project positions Emma Whelan (academic administrator), Jose Gracia (researcher), Fabio de Colle (researcher, to 19th Dec) Perikles Rammos (database architect, from 1st Sep)

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Research Associates Dr Peter Duffy, UCD; Professor A Lawrence FRSE, Royal Observatory Edinburgh; Professor Brian McBreen, UCD; Dr VF Polcaro, Istituto di Astrofisica Spaziale; Dr Mark Wilkinson, Institute of Astronomy, University of Cambridge; Dr Laura Norci, DCU; Dr Brian Espey, TCD; Dr Matthew Redman, NUIG; Dr Justin Donnelly, DIT; Mr Brendan Jordan; Dr Gareth Murphy, Grenoble; Dr Stephen O'Sullivan, UCD; Dr Dazhuang Zhou, Houston; Mr John Walsh, TCD; Dr Brenda Frye, DCU (from 5 Sep).

3 Research Reports

3.1 Brown Dwarf Outflow Studies

Emma Whelan and T. P. Ray

Work on outflow activity from brown dwarfs remained a strong focus of activity throughout the year. Further ESO observing time was granted for this project and using this data, plus spectra taken from the ESO data archive, a further three BD outflows were discovered and analysed. This brings the total known to five. One paper was accepted by ApJ letters in December 2008 and a second is in preparation. These optical outflows are similar to those driven by Classical T Tauri stars and they are now assumed to be scaled down from T Tauri outflows. Interestingly, analysis also revealed new information on the disks of these brown dwarfs. It is now obvious that planet forming processes, seen to be active in the disks of low mass protostars are also at work in brown dwarf disks (Whelan et al 2008, accepted). Other work included the study of protostellar jet launching at high angular resolution using spectro-astrometry and integral field spectroscopy, measurements of disk rotation in T Tauri disks using spectro-astrometry, and the building of the JETSET database of jet observations. Observing time on both the WHT and the VLT was granted in 2008 for the study of jet launching. In December 2008, E Whelan was awarded a Marie Curie Individual Fellowship, to continue her studies of jet launching; she will begin this fellowship in Spring 2009.

3.2 First Detection of an Atomic Jet from an Embedded Protostar

T. P. Ray with O. Dionatos, B. Nisini and JETSET Consortium Members

Deep Spitzer spectra were obtained along the molecular jet from the highly embedded protostar L1448-C. Atomic lines from the fundamental transitions of [Fe II], [Si II], and [S I] have been detected for the first time, showing the presence of an embedded atomic jet at low excitation. Pure rotational lines of molecular hydrogen were also found. From the different line ratios, it was found that conditions in the atomic jet were very different from those of more evolved sources. In addition only a fraction (0.05-0.2) of Fe and Si was observed to be in gaseous form, indicating that many refractory elements are still locked up in dust in such early-stage jets. Moreover a comparison with the SiO abundance recently derived in the jet from an analysis of several SiO submillimeter transitions shows that the Si/SiO abundance ratio is approximately 100. It follows that most of the silicon released from grains by sputtering and grain-grain collisions remains in atomic form.

3.3 Detailed Observational Studies of Stellar Outflows

Linda Podio

The aim of this research is to investigate the properties of stellar jets both on large and small scales, in order to derive stringent observational constraints on the theoretical models proposed for the jet launching and propagation. As one approach, we are using the spectro-astrometric technique to investigate the origin of permitted lines which are easily excited in the circumstellar region of young accreting stars. These lines may include contributions from both the accretion columns and the outflowing material, and thus their analysis can shed light on the central engine for the jet launching and its relationship with magnetospheric accretion. As another approach, we are applying spectral diagnostic techniques to analyse atomic and molecular forbidden lines which are excited in the shocks caused by the jet interaction with the interstellar medium. These techniques are very effective in deriving the physical/dynamical conditions of the gas in the jet and to investigate the shock structure.

3.4 Automatic Pipeline from Jet Simulations to Synthetic Observations

Jose Gracia

One of the most annoying problems in astrophysics is the fact that observations record photon flux in a detector far away from the source, while models predict the plasma state in terms of density, temperature, chemical composition, etc. However, calculating the plasma emission is highly non-trivial, in particular for thermal emission line processes in proto-stellar jets and accretion disks. OpenSESAME – a tool to calculate synthetic emission maps and spectra from MHD simulations or analytical models – was developed and made publicly available on the institute's webpage. Modellers and observers wishing to quantitatively compare their results, feed OpenSESAME with numerical simulations and detector characteristics and obtain synthetic observations that can be analysed exactly the same way as their real counterparts.

3.5 MHD Models for Jets

Jose Garcia

A project to develop MHD models and synthetic synchrotron emission maps for the jet of M87 was completed. This model for the first time quantitatively reproduces such key observational constraints as the opening angle over several orders of magnitude in distance from the core, the pronounced limb-brightening, position and magnetic field in the optical knot HST-1, and the jet to counter-jet brightness ratio.

Jose Gracia also concluded several projects related to MHD jet formation processes. Together with collaborators at Univ Shinshu (Taiwan) and Univ Athens (Greece), they could show that under resistive MHD conditions typical MHD jet formation configurations may not reach steady-state as they would in ideal MHD. Using the tool OpenSESAME to calculate synthetic emission maps, they also showed that standard self-similar MHD disk-wind solutions cannot easily reproduce the observed width of YSO jets, but need to be truncated at a finite distance. The truncation radius is consistent with observational constraints on the size of the disk-wind launching region.

3.6 High Resolution Spectroscopy of Brown Dwarfs

Carlos del Burgo

CdB has been working on the comparison of atmosphere models with high-resolution spectroscopy of brown dwarfs obtained with the spectrograph NIRSPEC (Hawaii, USA). The results of this work has been submitted to Astronomy and Astrophysics (del Burgo et al. 2008). CdB has regularly visited the IAC to work with his collaborators on these projects.

3.7 Ultra-precise Photometry from Space

Carlos del Burgo

CdB has been leading a multidisciplinary group of engineers and scientists aimed at developing the conceptual optical design of a low-resolution space-born optical spectrograph that is principally motivated to study FGK stars and transiting extra-solar planets. The instrument is designed to be on-board a micro-satellite. Microsatellites will offer an extremely economical means to obtain the large quantity of space-based measurements that will be vital in the future if we are to properly study the full range of transiting planet discoveries. The instrument must be capable of measuring ultra-precise optical spectro-photometry of point-like sources, in particular, bright solar-type stars. The expected precision to be achieved is better than 5 micro-magnitudes. This precision is unreachable even from large-aperture ground-based facilities due to scintillation noise resulting from air turbulence in the earth's atmosphere and variable weather conditions that hinder long-term observations.

CdB is associated partner leader of the FP7 Marie Curie ITN network RoPACS (Rocky Planets around Cool Stars), which is a pan European consortium including 10 research institutes of 6 countries and the industrial partner Astrium. RoPACS is focussed to discover and study extra-solar planets around cool stars, which are the most common potential planet hosts.

SCHOOL OF COSMIC PHYSICS

ASTRONOMY AND ASTROPHYSICS

3.8 Kuiper-Belt Objects

Carlos del Burgo

CdB is a team scientist of the Key Herschel programme DUNES (DUst around NEArby Stars), granted 140 hours. DUNES will use the unique photometric capabilities of Herschel to perform a deep and systematic survey of faint, cold debris disks around nearby FGK stars. Our sample is sensitivity-limited, volume-limited (below 20 pc), with stars of stellar ages ranging from about 0.1 to 10 Gyr. Some M-and A-type stars will be observed in collaboration with DEBRIS Herschel OTKP, so that the whole sample spans stellar masses from 0.2 to 2 solar masses. PACS and SPIRE photometric observations at wavelengths between 70 and 500 microns will be performed to characterize, model and constrain the disks. Our programme will make possible to find and study faint extra-solar analogues to the Edgeworth-Kuiper Belt objects. Also granted observing time to perform follow-up observations. CdB visited LAEFF and UAM to participate in meetings and work on the preparation of the additional data.

3.9 Shells in Elliptical Galaxies

Carlos del Burgo

CdB lead a paper on NGC 5982 (del Burgo, Carter & Sikkema 2008, A&A, 477, 105). A figure of the paper was selected as cover of A&A. The distribution of dust traced by optical obscuration (as seen by HST optical data) and infrared emission (as seen by Spitzer infrared data). Our HST data gauge small amounts of dust in the central regions of the sample, while the Spitzer data reveals the presence of a significant amount of cold dust forming a central disk in NGC 5982. In this galaxy shells are detected for the first time from mid-infrared emission and two new external shells are found (del Burgo et al. 2008). We analysed the colours of a prominent shell revealing its blue V-I and [3.6]-[4.5] colours with respect the underlying galaxy.

3.10 An ACS Treasury Survey of the Coma Cluster

Carlos del Burgo

The ACS Coma Cluster is an HST Treasury programme (ID: GO10861) that was awarded 164 orbits in Cycle 15 to perform a survey of thousands of galaxies down to $M_V - 9$ mag in the filters F475W and F814W. The survey was completed by 28% and interrupted due to critical technical problems with the ACS. CdB has been co-I of a proposal submitted to the HST to continue the analysis of Coma Cluster using also near-infrared observations. CdB visited the Liverpool John Moores University to collaborate with Prof. Dave Carter on the analysis of the HST/ACS images.

3.11 La Palma International Time Programme: Fossil Groups

Carlos del Burgo

CdB is co-I of a La Palma International Time Programme that has been granted 26 observing nights. The objective is to understand the merging history and evolution of fossil groups. This will be achieved by studying the observational properties of the brightest group galaxies and their environment. CdB has participated in the run of observations of November 2008.

3.12 Interstellar Medium of the Milky Way

Carlos del Burgo, with collaborators in the IAC

CdB has been working on the analysis of the anomalous emission detected in a few dust clouds with Prof. Rafael Rebolo and collaborators (IAC, Spain).

3.13 Formation of Structure in Low-Beta Regions of the ISM

Andy Lim

Absorption observations indicate that significant fluctuations in physical conditions in interstellar clouds exist on scales comparable to, or even smaller than, the dissipation length associated with ion-neutral friction. Earlier work on the behaviour of fast-mode MHD waves in magnetically-dominated regions of the Interstellar Medium showed that such waves can produce large density contrasts in regions where their behaviour is nonlinear. The non-linear steepening of the waves leads to a significant slow-mode component in the system which can generate large density contrasts.

Previous work with 1D and 2D simulations has concentrated on detailed dissipation microphysics and simple geometries. I am now performing 3D simulations of these systems using an ICHEC class B project obtained for this purpose with a view to investigating more complex geometries and whether the peak densities achieved can be enhanced by collisions in full 3D. Although, one might not, in general, expect the structures generated to collide in a 3D system, this might be more likely in this situation due to the constraining effect of the strong magnetic field.

Future work using the same ICHEC project will investigate whether shear boundary layers, such as are found at the surfaces of Giant Molecular Clouds in active star-forming regions, are a suitable source of the high-frequency waves which are the most efficient at generating structure.

3.14 MHD Simulations of Star-forming Regions

Andy Lim

Star-forming regions of the ISM are typically observed to have a low plasma parameter, β (ratio of gas pressure to magnetic pressure, $\beta = P_g/P_m$) and many studies of structure formation in such regions (including that above) have assumed magnetically dominated initial conditions. They have not, however, addressed the question of how such low- β regions can arise. Following an earlier study of a highly idealised situation in which a spherical cloud of gas with moderate β is compressed by a higher external pressure (which was published in ApJL) I am studying several other situations in which a cloud can find itself in a region of higher pressure. For example, a cloud may be overtaken by a shock wave generated by the overlapping supernova remnants from an OB cluster, or the cloud and its surroundings may be subjected to a general systemic compression upon entering the density wave of a spiral arm.

In thermally unstable gas, these types of phenomena can lead to a reduction in the plasma parameter of up to two orders of magnitude, which can accelerate star-formation in GMCs which are in the early stages of their lives. Initial 2D axis-symmetric simulations are encouraging and I have prepared a proposal for an ICHEC class B project to perform full 3D simulations to be submitted shortly.

3.15 Radiative Effects in the Interstellar Medium

J Mackey and A Lim

J. Mackey has continued to work on developing a modular Magneto-Hydrodynamics (MHD) code with ionising radiative transfer, in order to study certain radiative effects in the interstellar medium. Development and testing has taken somewhat longer than anticipated, but is now complete enough to begin testing theories relating to the evolution of ionised Hydrogen regions (HII regions) which grow around young massive stars. The project was awarded 275,000 hours of computer time on the new ICHEC supercomputing system, "Stokes," enabling Mackey and Lim to perform state of the art computational studies of the growth of HII regions. They are currently analysing and improving their code's performance on the new system, and in early 2009 will run the simulations they have prepared. Analysing the results of these simulations will be a major part of JM's Ph.D. thesis.

3.16 Simulated Polarimetric Observations of Stellar Jets

Andy Lim with Rachel Curran (Palermo)

Polarimetry is at the forefront of modern methods for the measurement of astrophysical magnetic fields. This project is in collaboration with Rachel Curran (ex-DIAS) and aims to compute the expected polarised emission from dust (and possibly CO/H₂) in the molecular knots which form in the stems and cocoons of jets from Young Stellar Objects.

Since the mechanisms producing this emission occur on fast timescales we intend to post-process the emission from pre-calculated jet models. To this end A Lim has performed a series of axisymmetric simulations of jets with varying magnetic field strengths and topologies; using an adaptive mesh such models can be run on a reasonably powerful PC. These simulations include a small chemical network incorporating the dominant paths of H₂ formation and destruction, and we are currently working on a microphysics algorithm to determine the expected emission and polarisation from the numerical data.

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These results will be directly comparable to polarimetric observations from facilities such as ALMA and our objective is to compare the physical conditions resulting in polarised emission from our models with those inferred from similar emission in real objects. This will allow us to estimate the veracity of the measurement of astrophysical magnetic fields which is still a notoriously difficult endeavour.

3.17 Computational Studies of ISM Turbulence

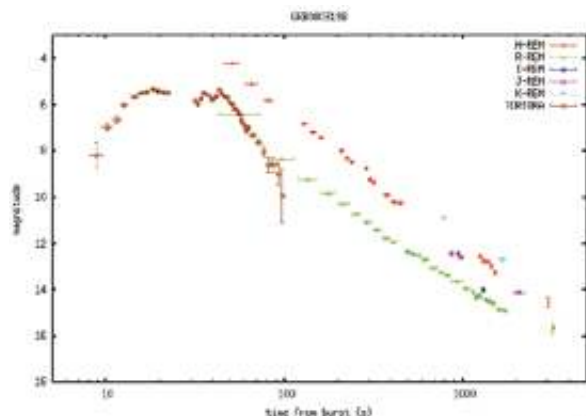
T. Downes

The decay of turbulence in a partially ionized and magnetised medium is being studied using the national capability computing resource (BlueGene). The code uses a novel numerical scheme which allows an explicit treatment of both Hall and ambi-polar diffusion effects. These will be the first simulations to include these effects at this level of detail and is expected to throw light on both the question of the decay and the statistical properties of turbulence in molecular clouds.

3.18 Gamma Ray Bursts: REM Telescope Observations

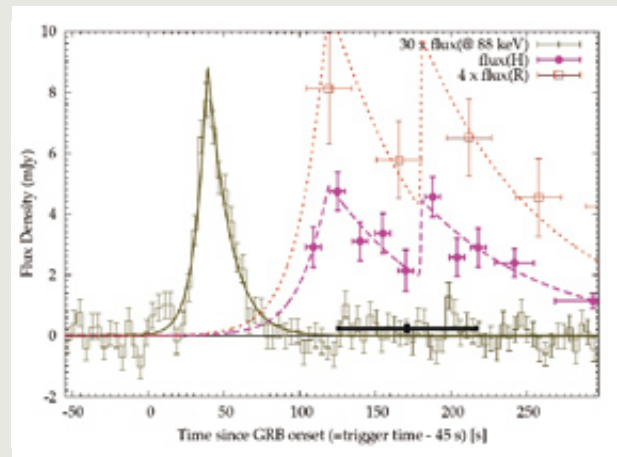
S. Vergani, P. Ward, E.J.A. Meurs, L. Norci (DCU), E. Molinari, S. Covino, et al. (Brera Observatory)

Several Gamma Ray Burst (GRB) afterglows were detected throughout the year with the REM Telescope. An outstanding case was GRB080319B, the so-called naked-eye GRB (as it had reached naked-eye visibility at peak brightness). This generated a well-covered early lightcurve, which is now being analysed.



The very early lightcurve of GRB080319B, the so-called "naked-eye burst". Data from the REM telescope and the Russian TORTORA camera mounted on REM.

Fits to the lightcurves of GRB070311 (detected by the INTEGRAL satellite) for REM data and also X-ray data from the Swift satellite have been analysed in terms of flares or pulses, for which refreshed shocks due to other shells ejected in the GRB event as well as density bumps in the surrounding medium are considered.



GRB070311 data at gamma-rays (crosses, from INTEGRAL), optical R-band (squares, REM data) and near-IR H-band (circles, REM data) fitted with a pulses model.

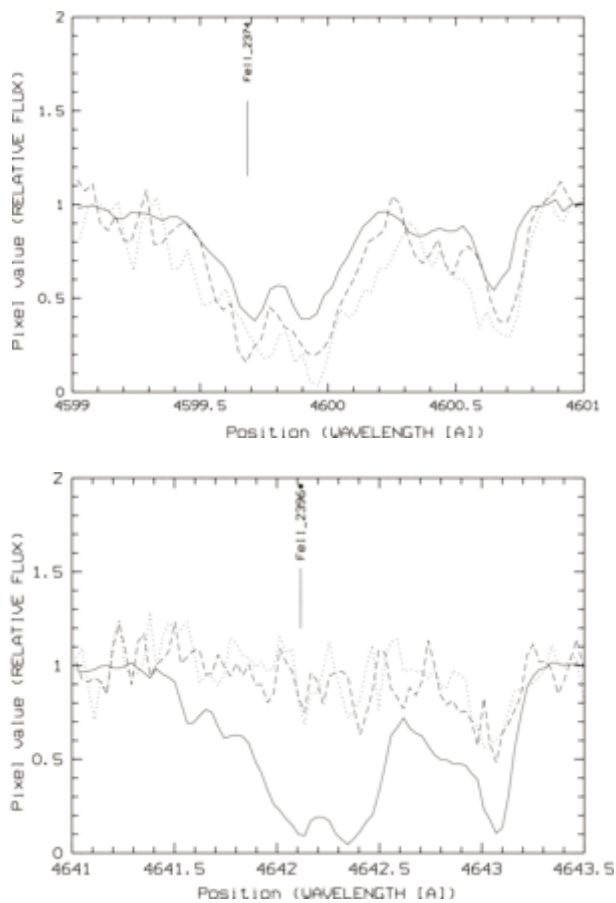
Further lightcurves that were studied with REM data include GRB070707, GRB071010A and GRB060908. The results obtained for the short/hard GRB070707 indicate a very faint emission level for the host galaxy and caution that proposed associations with bright, offset galaxies may be fortuitous, as the host galaxies may be too dim to be detected easily.

3.19 High Resolution Echelle Spectroscopy of GRB Afterglows

P. Ward, S. Vergani, E.J.A. Meurs, L. Norci (DCU), F. Fiore, V. DELia, S. Piranomonte (Rome Observatory)

High-resolution echelle spectroscopy is a relatively new and exciting tool for GRB astronomy. Data may now be obtained only minutes after a burst has occurred, which is important because of the transient nature and decreasing brightness of the afterglows. The echelle spectroscopy highlights the presence of intervening material along the line of sight, in the immediate surroundings of a burst as well as in separate intervening systems.

Observations of the naked-eye burst GRB080319B led to the highest signal-to-noise, high-resolution spectrum of a GRB afterglow ever obtained, with the strongest FeII fine structure lines ever observed for a GRB. The decrease in optical depth of these lines a few hours later demonstrates that the fine structure lines are due to UV pumping. The six absorption components of the main absorption system are found to be at distances 2-6 kpc from the GRB site.



Variability of normal (Above) and fine structure (Below) transitions of FeII. Time runs in the order full, dashed and dotted lines covering the first three hours of the outburst.

Detailed echelle spectra were also secured for the burst GRB080330. Assuming again UV pumping, the bluest absorption component in the host galaxy system appears to be much closer in this case, at about 0.3 kpc from the GRB site. For this study, as well as the previous one on GRB080319B, we employed a novel time-dependent photo-excitation code.

Several high-resolution echelle spectra of GRB afterglows, obtained with the VLT/UVES instrument over the past ca. 6 years, have been employed in a study of intervening absorption systems featuring MgII lines. A previously found excess of strong MgII absorbers in GRB afterglow spectra, compared to QSO lines of sight, appears to be less strong than had been concluded before. The picture that emerges from this study is that dust is not likely to be an important factor in causing a MgII excess for GRBs, while on the other hand a subtle gravitational lensing effect may be the reason for such a bias. The spectra also allow to search for the so-called damped Lyman-systems, which appear to occur at a higher rate than is found for QSO lines of sight. As these systems tend to be encountered relatively close to the GRBs, it might be that (part of) this gas is somehow associated with the GRB.

3.20 Echelle Spectroscopy of Runaway Stars

E.J.A. Meurs, C. O'Maoileidigh, L. Norci (DCU), C. Rossi and V.F. Polcaro (Rome)

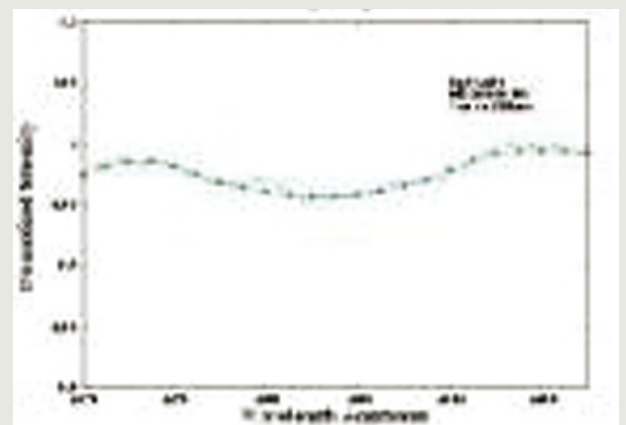
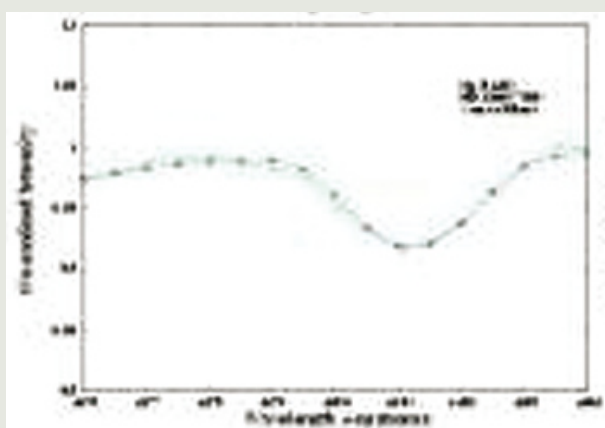
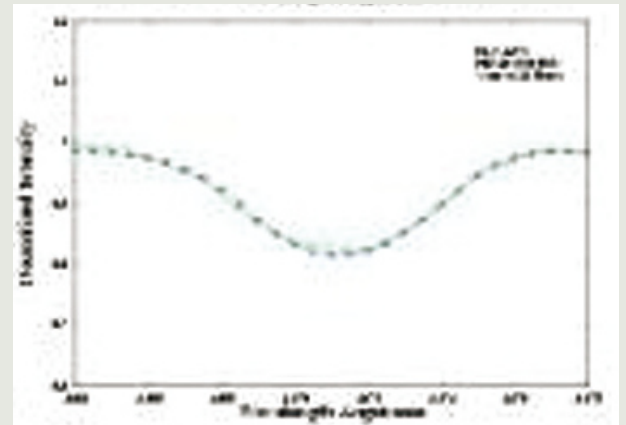
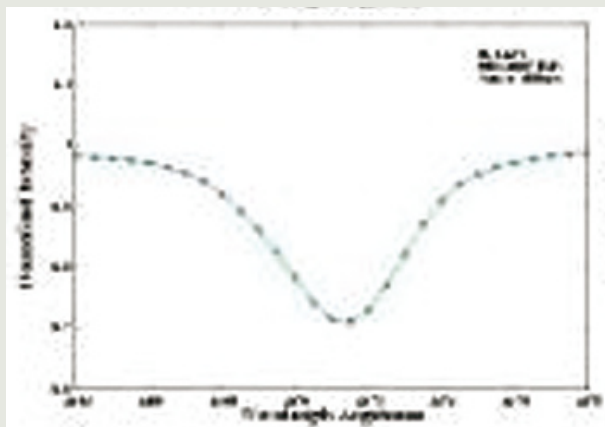
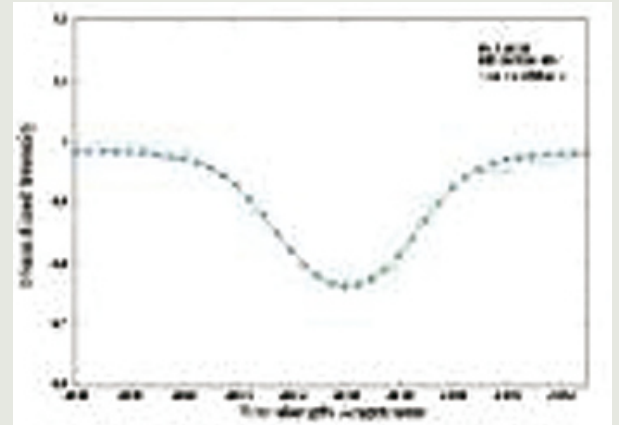
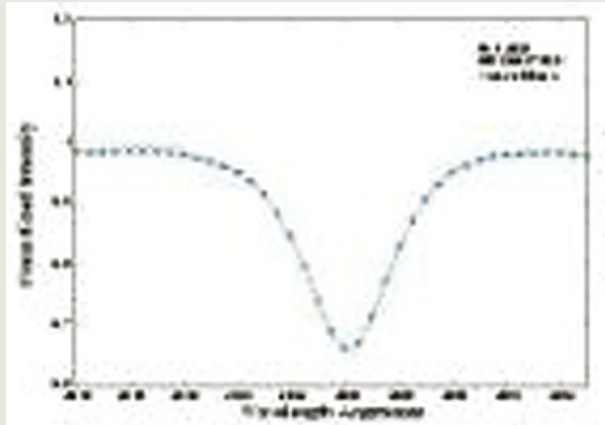
Blaauw suggested in 1993 that excess rotation in runaway stars may be an indicator of close binary evolution as increased rotational velocity is a natural consequence of mass transfer to the companion star prior to the supernova explosion of the primary star. The implication is that the runaways were ejected via the supernova in a binary scenario.

Observations of OB runaway stars (without rotational velocity information) carried out at Loiano Observatory (Italy) demonstrate the excess rotation rates for O-type runaway stars, while this is not found for B-type runaways (that then are likely to have been dynamically ejected). A master list has now been generated that includes our new observational results as well as the rotational velocity values that were already available in the literature.

Observations at Loiano Observatory have been continued this year for OB stars generally, in order to measure radial velocities for OB stars that still lack a radial velocity determination. Again this is pursued with high-resolution echelle spectroscopy. In this way, a census of all Northern OB stars down to magnitude $V=8$ has almost been completed. The main objective is to find further, hitherto unrecognized runaway stars on the basis of larger than normal radial velocities.

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Examples of synthetic line profiles (blue) fitted to observed line profiles (green) for HD220057 (left, moderate rotational velocity of $\approx 100 \text{ km s}^{-1}$ and HD201901 (right, high rotational velocity of $\approx 225 \text{ km s}^{-1}$). The upper two panel pairs are for HeI lines, the bottom for a HeII line.

3.21 OB Runaway Star Lightcurves

E.J.A. Meurs, S. Reynolds (DCU)

High-precision photometric lightcurves of OB runaway stars may offer an alternative avenue for recognizing any collapsed companions (i.e., neutron stars) to these stars. The presence of a (close) collapsed companion would be noticeable from the gravitational distortion of the shape of the normal star (the runaway star as such), which causes small, periodic light variations.

Recognizing a collapsed companion is relevant in view of the likely occurrence of a supernova in a binary that led to the observed high space velocities of these stars. A very appropriate database that is used for this investigation is provided by the results of photometric measurements that were carried out with the Hipparcos satellite. Other methods that have been availed of for finding such collapsed companions, but have not led to positive conclusions, relied on X-ray emission, pulsar radio signatures, or radial velocity variations.

3.22 High-energy Emission from Young Stellar Clusters

E.J.A. Meurs, P. Kavanagh (DCU), L. Norci (DCU)

The high-energy emission from very young stellar clusters may be modelled without yet having to deal with complications introduced by close-binary evolution. We have analysed X-ray data for the very young Galactic Super Star Cluster Westerlund 1. New evidence was uncovered to support a thermal origin for the diffuse hard X-ray emission component in this cluster, revealing a 6.7 keV Fe line. As to possible explanations for this line, a cluster wind as origin is likely, but not a supernova remnant, while at this stage the role of Pre-Main Sequence stars is not fully assessed yet.

X-ray spectrum, observed with XMM-Newton, for the inner 2' radius region of the very young star cluster Westerlund 1. The line feature at 6.7 keV is from Fe and indicates the thermal nature of the diffuse X-ray emission. The thermal model fit is shown with fit residuals in the lower panel.

3.23 High-energy Sources in Galaxies

E.J.A. Meurs, N. Nooraee

A project was started to study the spatial distribution of likely black hole binaries in several galaxies, using a recently uncovered luminosity break in X-ray Luminosity Functions for these objects.

3.24 Supernova Candidates in the Solar Neighbourhood

E.J.A. Meurs, J. O'Reilly (DCU)

State-of-the-art stellar evolution models were employed for selecting likely supernova candidates among highly evolved massive stars in the (wider) solar neighbourhood. When exactly these stars will explode cannot however be predicted with any certainty.

3.25 AGN Contributions to HDF Galaxies

E.J.A. Meurs, C. Helly (DCU)

For a relevant colour versus spectral slope diagram, grids were calculated displaying redshift and an active nucleus component for several galactic models. A comparison of these grids with galaxies observed in the Hubble Deep Fields indicates that Active Galactic Nuclei likely contribute to the emission of most of these high-redshift galaxies.

3.26 X-ray Observations of the 2007 PSR B1259-63 Periastron Passage

M. Chernyakova, A. Neronov (ISDC), F. Aharonian, Y. Uchiyama (SLAC), T. Takahashi (JAXA)

PSR B1259-63 is a 48 ms radio pulsar in a highly eccentric 3.4 year orbit with a Be star SS 2883. Unpulsed Γ -ray, X-ray and radio emission components are observed from the binary system. It is likely that the collision of the pulsar wind with the anisotropic wind of the Be star plays a crucial role in the generation of the observed nonthermal emission. The 2007 periastron passage was observed in unprecedented details with Suzaku, SWIFT, XMM-Newton and Chandra missions. We have analyzed the data and compared the results with previous observations. Using the multi-mission data, we are able, for the first time, to study the details of the spectral evolution of the source over a ~ 2 months period of the passage of the pulsar close to the Be star. New data confirm the spectral hardening to the photon index smaller than $\Gamma=1.5$ observed this time during a local minimum of the flux in the middle of a period of passage of the pulsar through the equatorial wind of the companion Be star. We discuss the implications of the observed spectral evolution. Unfortunately the lack of simultaneous data in the TeV energy band prevents us from defining the nature of the observed spectral hardening and therefore on the origin (Inverse Compton or synchrotron) of the X-ray emission.

3.27 Study of the Longterm Variability of Gamma-ray Loud Binary LSI +61 303

M. Chernyakova, A. Neronov (ISDC)

The Be star binary LSI +61 303 is one of few currently known gamma-ray loud X-ray binaries. The spectrum of high-energy emission from the system extends up to TeV energies and the power output of the source is dominated by emission in the gamma-ray energy band. In this system the compact source is orbiting around the Be star along the elongated orbit with 26.496 days period.

The inhomogeneity of environment created by the stellar wind and radiation of the Be star leads to an “onion-like” structure of the system, so that emission in different energy bands is produced at different distance scales. The fraction of the total source power emitted in a given energy band depends on the time that high-energy particles spend in the corresponding “shell”. This, in turn, depends on the speed of escape of the high-energy particles. High-resolution radio observations show that the radio synchrotron emission from ~ 10 MeV electrons is produced at large distances, outside the binary orbit. The same population of electrons, most probably, produces the X-ray emission via inverse Compton scattering at smaller distances. Finally, close to the Be star, emission is suppressed because of the dominance of the non-radiative Coulomb loss.

Since the compact object moves along an elliptical orbit, the rate of injection of the high-energy electrons in the X-ray and radio emitting shells depends on the orbital phase. This determines the orbital modulation of the signal in radio and X-ray energy bands. In the radio band it is known that the signal exhibits modulation not only on the orbital, but also on the super-orbital time scale, with a period $P_s = 1667 \pm 8$ d (~ 4.6 yr).

Change of the properties of the disk on the super-orbital time scale leads to the change of the regime of escape of the 10 MeV electrons from the system. Since these electrons are responsible not only for the radio emission from the system, but also for the X-ray emission, the modulation of the escape regime should also lead to the super-orbital modulation of the orbit-folded lightcurve in the X-ray band.

Contrary to observations in the radio band, in which the source is regularly monitored on orbit-by-orbit basis, the X-ray observations of the system are sparse and the super-orbital modulation, similar to the one observed in the radio band was not reported before. Previous attempts to look for

it were based on the RXTE/ASM data and were inconclusive due to the relative weakness of the source. In our work we collect all the available X-ray observations of the system on the time scale of more than a decade. We show that these observations provide an evidence to the fact that the shape of the orbit-folded X-ray lightcurve changes on the several years time scale. Moreover, the phase of the X-ray maximum seems to “drift” in the same direction as the phase of the maximum of the radio lightcurve. However, the sampling of the X-ray lightcurve is at the moment not sufficient to reveal the details of the super-orbital modulation of the X-ray flux.

3.28 Molecular Clouds as Tracers of Cosmic Ray Acceleration

S Gabici

Theoretical studies of particle acceleration at non relativistic shocks were performed, with particular attention to expanding shocks of supernova remnants. Cosmic rays can escape the supernova remnants and interact with the surrounding gas. Within this framework, the radiative signatures that can be expected in the scenario in which a massive molecular cloud located close to the supernova remnant provides a thick target for cosmic ray interactions were studied. Gamma rays from such hadronic interactions are expected to dominate the total emission from the cloud, exceeding the energy output in other energy bands by an order of magnitude or even more. This suggests that molecular clouds illuminated by cosmic rays might explain at least some of the unidentified TeV sources detected by HESS, especially the “dark” sources which are bright at TeV energies but are characterized by the lack or the very low level of the emission at lower frequencies.

3.29 Particle Acceleration and Radiation at Sub Relativistic Shocks

S. Delaney, P. Dempsey, F. Aharonian and P. Duffy (UCD)

Diffusive shock acceleration in radiation dominated environments has previously been examined in non-relativistic flows by Vannoni, Aharonian & Gabici (2008). However most sources which are potentially radiation dominated, e.g. microquasars, are expected to contain mildly relativistic shocks. In this project we intend to extend the results of Vannoni, Aharonian & Gabici (2008) to mildly relativistic shocks. We are simultaneously developing a numerical code for particle acceleration at arbitrary velocity shocks. This will be tested against

the mildly relativistic code mentioned above and an extremely fast non-relativistic code we have already developed, before applying it to the ultrarelativistic shocks we expect in gamma ray bursts.

3.30 Time Dependent Relativistic Shock Acceleration with Turbulence Transmission

P. Dempsey and J. Tammi (Metsähovi Radio Observatory, Finland)

Using a semi-analytical method, similar to that developed in Dempsey & Duffy (2008) for examining particle acceleration and radiation at relativistic shocks, we have been able to determine the acceleration timescale and the temporal evolution of the particle distribution at arbitrary velocity shocks. Our results are consistent with those previously published in the non-relativistic limit (see Drury (1983) for a review) and also takes into account the details of turbulence transmission across the shock (see Vainio, Virtanen & Schlickeiser (2003) and Tammi & Vainio (2006).

3.31 Relativistic Shock Acceleration: a Hartree-Fock Approach

P. Dempsey and J. Kirk (MPIK Heidelberg)

Keshet & Waxman (2005) produced a simple formula for the power law index of particles accelerated at shocks of arbitrary velocity. While their formula fits previous values very well, their derivation contains several errors and their method fails to produce a pitch angle distribution that is consistent with previous numerical and semi-analytical work. By making certain analytical approximations we have produced power law indices that are close to those previously calculated, while simultaneously obtaining pitch angle distribution which agree with those found in early semi-analytic work.

3.32 Particle Acceleration by Multiple Parallel Shocks

J. Tammi (Metsähovi Radio Observatory, Finland) and P. Dempsey

Using both numerical and semi-analytical techniques we are examining particle acceleration in multiple parallel relativistic shocks. The non-relativistic results have been known for some time and by extending these results to the relativistic limit we hope to apply them to the internal shock models of gamma-ray bursts.

3.33 Shear Acceleration in Rotating Jets

P. Dempsey and F. Rieger (MPIK Heidelberg)

Internally rotating jets are expected to be present in a number of astrophysical sources including AGNs. We are considering the acceleration of energetic charged particles within such flows and examining the role of shear and centrifugal effects for efficient particle energization. We believe that shear acceleration could be particularly interesting in the context of hadronic models.

3.34 High-energy Non-thermal Astrophysics

Felix Aharonian

Activity in 2008 was related to several topics of High Energy Astrophysics with an emphasis on the phenomenological and theoretical studies of multi-wavelength properties of gamma-ray sources. As well as these topics being of certain interest in their own right, they are particularly motivated by the results obtained with the H.E.S.S. telescope array. Some studies have also been motivated within the framework of the two highest priority projects in Astroparticle Physics at present, namely CTA and KM3NeT. There is close collaboration also with the the Japanese Suzaku X-ray mission team (ISAS, Tokyo) and with the NANTEN team (Nagoya University) on CO observations of the interstellar medium, both wavelength intervals being of great importance in the identification and/or understanding of the nature of the very high energy gamma-ray sources. In the so called hadronic scenarios, gamma-radiation is accompanied by the production of high energy neutrinos. For this reason F. Aharonian is also interested and involved in projects related to high energy neutrino astronomy. In particular a series of theoretical calculations of TeV neutrino fluxes from different types of hadronic sources have been made in the context of design studies of the cubic kilometer volume underwater neutrino detector in the Mediterranean Sea (KM3NeT). At present the main scientific interests of F. Aharonian are related to the following research areas:

- origin of galactic cosmic rays, in particular in the context of particle acceleration and related broad-band emission in supernova remnants, propagation of cosmic rays in the Galactic Disk and their interactions with molecular clouds leading to the production of extended gamma-ray emission and high energy neutrinos

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- particle acceleration and interactions in radiation-dominated environments, in particular in the context of diffusive shock acceleration of electrons in SNRs and binary systems, as well as the acceleration of ultra-high energy protons in clusters of galaxies;
- binary pulsars and microquasars, in particular the magnetohydrodynamics of interactions of pulsar winds or black-hole jets with the stellar disk; time-dependent modeling of inverse Compton and synchrotron radiation of electrons accelerated in the relativistic outflows formed in binary systems
- gamma-radiation of AGN, in particular time-dependent modeling of electromagnetic and hadronic interactions in the inner jets of blazars with emphasis on formation of very hard intrinsic gamma-ray spectra, and modeling of broad band-emission from the large-scale jets of radiogalaxies
- acceleration and radiation processes in magnetospheres of underluminous supermassive black holes, in particular in Sgr A*, M87, and Centaurus A
- propagation of highest energy protons, nuclei and photons through intergalactic radiation and magnetic fields

3.35 The Puzzling MILAGRO Hot-spots

L Drury and F Aharonian

Early in the year the MILAGRO experiment produced a sky-map of the arrival direction of charged cosmic rays at energies around 10TeV showing two small "hot-spots" in the angular distribution. The very surprising aspect is the small angular extent of the spots, indicating a well-collimated if weak beam of hadrons which also appears to come from the direction of the local heliotail. A natural suspicion is albedo production of secondary neutrons in the heliotail, but analysis of this model has shown it to be incapable of producing a signal of the required strength. An alternative model based on loss-cone focussing and leakage of protons through a near-by magnetic mirror is suggested as the only plausible method of generating features on such a small angular scale.

3.36 The Plasma Temperatures in Supernova Remnants

L Drury, F Aharonian, D Malyshev and S Gabici

Many of the parameters (in particular the density and shock velocity) required in constructing models of specific supernova remnants are derived from X-ray observations, but there is considerable uncertainty as to the true electron and ion temperatures in the shock-heated gas filling these structures, and thus on the inferred parameters. We have attacked this problem from two different angles. On the one hand, we have asked the fundamental question; how cold can the post-shock gas be if the bulk of the energy dissipated in the shock goes into particle acceleration and not gas heating? In this extreme limit (strong acceleration and no wave dissipation in the precursor) we have shown that the post-shock gas temperature can be a rather small multiple of the upstream temperature so that "cold" SNRs appear possible. It is tempting to relate this to the observation that the strong TeV emitting shell remnants appear to be anomalously weak in thermal X-rays. The second approach we have adopted is a more formal study of minimal electron heating by Coulomb exchange using Chevalier's generalised self-similar models to describe the dynamics of the SNR.

3.37 Space Dosimetry

D O'Sullivan with Johnson Space Center, Houston

Following completion of measurement and analysis of the Matroshka-1 data, which was obtained by exposing a human phantom outside the International Space Station(ISS), attention was focussed on the Matroshka-2 project and work progressed steadily throughout the year. The Matroshka-2 project involved exposing the same phantom inside the Russian Zvezda module of the ISS from December 21, 2005 to December 22, 2006 (367 days). These two projects will result in a unique set of data for investigating the impact of cosmic radiation and solar energetic particles on human organs and provide important information for future long term missions such as those planned to Mars. With analysis nearing completion, initial results indicate that the ISS shielding decreases dose equivalent rates by approximately 56% inside the ISS and that the low and high linear energy transfer radiation contributions are 1/3 and 2/3 of the total, respectively. It is planned to use this information to help in shielding design for future space vehicles.

A proposal, (DOSIS), to map the radiation field inside the European Columbus Laboratory, which was launched to the ISS in Feb 2008, was successful and the DIAS/Houston detectors are collecting data in Earth orbit since that time. They are due to be returned early in 2009.

An extension of the DOBIES project, which is a collaboration between DIAS, the Belgian Nuclear Research Centre and the Czech Academy, was also included in the Columbus Laboratory on its first flight and the detectors were returned by the Russian Soyuz spacecraft in October 2008. Analysis will start in 2009.

4 International Collaborations

4.1 HESS, HESS-II

L Drury, F Aharonian, S Gabici, L Fallon The HESS experiment continued to have a very successful year of operations with many new detections and interesting results being published. Two highlights which stand out are the detection of TeV emission from the remnant of SN1006 and the detection of TeV emission from another non-blazar AGN, the strong near-by radio galaxy Cen A. Progress was made during the year with the construction of the steel frame for the HESS-II telescope (a single large dish) to be installed at the centre of the HESS-I array.

4.2 CTA

L Drury, F Aharonian, S Gabici

The Cherenkov Telescope Array project (CTA) a proposal to build on the great success of the second generation experiments HESS, MAGIC and VERITAS with a facility that will be an order of magnitude more sensitive and operate as a true observatory. At the end of the year the CTA project was included in the the roadmap of the European Strategic Forum for Research Infrastructures (ESFRI).

S Gabici is participating in the "Astrophysics and Astroparticle Physics" work package, whose aim within the CTA Design Study is to provide a summary of detailed physics goals to be investigated with CTA, and to define the required instrument performance. In particular he is Task Leader coordinating the activities of the work package for the topic: Cosmic Rays, Supernova Remnants and Molecular Clouds. L Drury contributed to the Observatory and Data working groups.

4.3 JETSET

T.P. Ray, JETSET Network Coordinator

The Jet Simulation, Experiment and Theory (JETSET) network operated very successfully throughout the year with some 50 collaborative publications between the various partners. Most of the contract positions for Early Stage Researchers (ESRs, i.e. PhD students) and Experienced Researchers (ERs, i.e. postdoctoral fellows) finished towards the end of 2008. In all cases the ESRs or ERs obtained host institution funded extensions, for example to finish their PhD, or new positions. The latter included some tenured posts for the ERs and offers of postdoctoral fellowships for ESRs.

Time was granted to the network on a number of world-class ground-based and space-based facilities including the VLT, Spitzer, Herschel (key programme status), HST and e-MERLIN (legacy programme status). Funding was also awarded to upgrade the MAGPIE laboratory jet experiment facility at Imperial College London and for a number of new multi-lateral collaborative programs between partners.

In 2008, both a school (in Galway) on the theme "High Performance Computing in Astrophysics" and an international conference (held in Rhodes, Greece) entitled "Protostellar Jets in Context" were organised. Details of these events, which were managed by the section in collaboration with NUI Galway and the University of Athens respectively, are given in sections 12.1 and 12.3.

4.4 KM3NeT

F. Aharonian and L. Drury

The section contributed extensively to the writing and the editing of the chapter "Physics, analysis and simulations", of the Conceptual Design Report, in particular the sections on supernova remnants, molecular clouds (where S Gabici made significant contributions), and diffuse emission from the inner galaxy. Moreover, the estimate of the diffuse neutrino flux from the inner Galaxy, included as preliminary results in the Conceptual Design Report, have been published as a separate paper in cooperation with the Km3NET Consortium.

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4.5 MIRI

T. P. Ray with B. Espey (TCD) and B. Frye (DCU)

MIRI is the mid-IR instrument for the James Webb Space Telescope (JWST), the successor to the very successful Hubble Space Telescope, and it is due for launch in 2013. It provides imaging, coronagraphy and integral field spectroscopy over the 5-28 μ m wavelength range and it is the only instrument cooled to 7K by an on-board dedicated cryostat. This temperature is much lower than the passively cooled 40K of the rest of JWST and maintaining it introduces unique challenges.

The flight model (FM) design of the MIRI Optical System is now complete and the spectrometer and imaging elements are currently being assembled in the Astronomy Technology Centre (ATC) in Edinburgh and the Commissariat à l'Énergie Atomique (CEA) in France for final integration and testing in 2009 of the whole instrument at the Rutherford Appleton Laboratory (RAL). The Focal Plane Module containing the MIRI detectors is being manufactured by JPL.

Testing of the Verification Model (VM) was completed in 2008 at RAL and B. Frye assisted with the testing campaign (see figure). First-light was readily achieved and results from both imaging and spectroscopic modes were excellent after minor alignment problems were solved. This has given the team confidence in building the FM. Some modifications to the Filter Wheel Assembly (FWA) carrying the DIAS supplied mid-infrared filters, are also being made.



MIRI Verification Model (VM) encased in a Mylar blanket prior to vacuum cryostat testing

4.6 NAHUAL

C. del Burgo

Carlos del Burgo is the Project Scientist and co-PI of NAHUAL, a near-infrared (0.9-2.5 μ m) high-resolution spectrograph ($R=65000$) for the 10.4-m GRANTECAN telescope on the Observatorio Roque de Los Muchachos (La Palma, Spain). NAHUAL is developed in the framework of an international collaboration led by the Instituto de Astrofísica de Canarias (IAC, Spain) with the participation of research centres in Germany, Italy, Portugal and Ireland. CdB is the leader of a group of engineers that is working on the acquisition camera, the grating mounting, the atmospheric dispersion compensator, a slit-viewing camera and the overall optics of NAHUAL. NAHUAL will be a stable and highly repeatable cryogenic system, able to measuring radial velocities with a precision of 1 m/s in the wavelength range from 1 to 2.4 microns. The main goal is the search or rocky extrasolar planets around cool stars.

In the last three months of 2008, CdB has been coordinating the science working groups and the calibration group of NAHUAL. The document that describes the NAHUAL instrument concept has been presented to the scientific community and two external referees in the GTC/Exoplanet and V NAHUAL workshop (September 2008). The referees have reported positively about NAHUAL.

4.7 REM

E. Meurs

The Rapid Eye Mount (REM) Telescope is a robotic telescope with the principal aim to provide quick follow-up observations of Gamma Ray Bursts detected by satellite Γ -ray observatories. The telescope has a 60 cm diameter mirror, is located at La Silla (Chile), and carries Near-Infrared as well as optical cameras. The REM project is led by Brera Observatory in Milan-Merate (Italy), with Irish participation by DIAS and UCD.

5 Contributions to the National e-Infrastructure

5.1 e-INIS

The e-INIS project aims to develop an integrated national e-infrastructure building on the three existing service providers, HEAnet as the National Research and Education Network service, ICHEC the Irish Centre for High-End Computing as the national HPC service, and Grid-Ireland as the National Grid Infrastructure provider, together with specific centres of expertise in partner institutions. It is one of the national collaborations funded under PRTL-4. A major milestone was the appointment of Dr Keith Rochford as project coordinator and outreach officer in June. The other major development was the completion of the first major capital project with the replacement of ICHEC's capacity cluster (Walton) with a new SGI system named Stokes. The new system was delivered in November and the Walton system decommissioned in December. HEAnet made progress with implementing the advanced optical network envisaged in the proposal, and plans for the national data store were well advanced by year end.

5.2 Blue Gene

The national capability computing system, commissioned by DIAS on behalf of the third level research community, completed its first full year of operations. The system was formally launched by the Tánaiste and Minister for Enterprise, Trade and Employment, Mary Coughlan TD in the presence of Larry Hirst, Chairman of IBM EMEA, at the Irish Centre for High-End Computing's annual seminar held in the Royal Irish Academy on 30th Oct (see Fig. 1).

The system consists of one rack of BlueGene/P (named Schroedinger) and one rack of Blue-Gene/L (named Lanczos) with a shared front end. It is hosted in the HEAnet national hosting centre and operated by the Irish Centre for High-End Computing as part of their portfolio of services. As expected take-up of the system was initially rather slow, but then increased steadily to the point that by year-end it was fully occupied and supporting some six distinct class-A projects. By September two user groups had advanced to the point where they could request access to larger scale IBM facilities in the US (as provided for in the contract).



Figure 1: L Drury (far right) explaining the importance of the BlueGene facility to an Tánaiste, Mary Coughlan TD at the official launch in the RIA. Also in the picture (from left), Michael Kelly, Chairman of the HEA; Dr Damien Thompson, Tyndall National Institute; Larry Hirst, chairman of IBM EMEA.

6 Publications

6.1 Refereed Publications

Note that all the publications listed as Aharonian et al (HESS collaboration) include F. Aharonian, L. Drury and S. Gabici as co-authors from DIAS. Almost all these publications are available online as a private library under the ADS using the following URL: http://adsabs.harvard.edu/cgi-bin/nph-abs_connect?library&libname=Ref2008&libid=4794ca7845

1. Vergani, S. D., Malesani, D., & Molinari, E.: The Interplay of Prompt and Afterglow Emission in GRB 060418 International Journal of Modern Physics D (2008) 17 1343-1349.
2. Vergani, S. D. & Guidorzi, C.: GRB 070311: a Common Origin for the Prompt and Afterglow Emission International Journal of Modern Physics D (2008) 17 1359-1362.
3. Vergani, S. D., et al.: Do all Short GRBs have AN Associated Host Galaxy? the Case of GRB 070707 International Journal of Modern Physics D (2008) 17 1363-1369.
4. Del Burgo, C., Carter, D., & Sikkema, G.: Spatial distribution of dust in the shell elliptical NGC 5982 Astronomy and Astrophysics (2008) 477 105-116.
5. Aharonian, F., et al.: HESS very-high-energy gamma-ray sources without identified counterparts Astronomy and Astrophysics (2008) 477 353-363.

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ASTRONOMY AND ASTROPHYSICS

6. Aharonian, F., et al.: HESS observations and VLT spectroscopy of PG 1553+113 *Astronomy and Astrophysics* (2008) 477 481-489.
7. Neronov, A. & Chernyakova, M.: A Rotating Hollow Cone Anisotropy of TeV Emission from Binary Systems *Astrophysical Journal* (2008) 672 L123-L126.
8. Khangulyan, D., Aharonian, F., & Bosch-Ramon, V.: On the formation of TeV radiation in LS 5039 *Monthly Notices of the Royal Astronomical Society* (2008) 383 467-478.
9. Aharonian, F., et al.: Upper limits from HESS active galactic nuclei observations in 2005-2007 *Astronomy and Astrophysics* (2008) 478 387-393.
10. Rieger, F. M. & Aharonian, F. A.: Variable VHE gamma-ray emission from non-blazar AGNs *Astronomy and Astrophysics* (2008) 479 L5-L8.
11. Aharonian, F., et al.: Observations of the Sagittarius dwarf galaxy by the HESS experiment and search for a dark matter signal *Astroparticle Physics* (2008) 29 55-62.
12. Podio, L., et al.: Tracing the origins of permitted emission lines in RU Lupi down to AU scales *Astronomy and Astrophysics* (2008) 480 421-430.
13. Dieckmann, M. E., Shukla, P. K., & Drury, L. O. C.: The Formation of a Relativistic Partially Electromagnetic Planar Plasma Shock *Astrophysical Journal* (2008) 675 586 595.
14. Aharonian, F., et al.: Discovery of very high energy gamma-ray emission coincident with molecular clouds in the W 28 (G6.4-0.1) field *Astronomy and Astrophysics* (2008) 481 401-410.
15. Aharonian, F., et al.: Discovery of VHE Γ -rays from the high-frequency-peaked BL Lacertae object RGB J0152+017 *Astronomy and Astrophysics* (2008) 481 L103-L107.
16. Uchiyama, Yasunobu & Aharonian, Felix A.: Fast Variability of Nonthermal X-Ray Emission in Cassiopeia A: Probing Electron Acceleration in Reverse-Shocked Ejecta *Astrophysical Journal* (2008) 677 L105-L108.
17. Amato, Elena, Blasi, Pasquale, & Gabici, Stefano: Kinetic approaches to particle acceleration at cosmic ray modified shocks *Monthly Notices of the Royal Astronomical Society* (2008) 385 1946-1958.
18. Bosch-Ramon, V., Khangulyan, D., & Aharonian, F. A.: Non-thermal emission from secondary pairs in close TeV binary systems *Astronomy and Astrophysics* (2008) 482 397-402.
19. Chrysostomou, A., et al.: Investigating the transport of angular momentum from young stellar objects. Do H2 jets from class I YSOs rotate? *Astronomy and Astrophysics* (2008) 482 575-583.
20. Melnikov, S., et al.: A HST study of the environment of the Herbig Ae/Be star LkH 233 and its bipolar jet *Astronomy and Astrophysics* (2008) 483 199-208.
21. Aharonian, F., et al.: Exploring a SNR/molecular cloud association within HESS J1745303 *Astronomy and Astrophysics* (2008) 483 509-517.
22. Aharonian, F., et al.: Discovery of very-high-energy Γ -ray emission from the vicinity of PSR J1913+1011 with HESS *Astronomy and Astrophysics* (2008) 484 435-440.
23. Raga, A. C., et al.: A Latitude-dependent Wind Model for Mira's Cometary Head *Astrophysical Journal* (2008) 680 L45-L48.
24. Bogovalov, S. V., et al.: Modelling interaction of relativistic and non-relativistic winds in binary system PSR B1259-63/SS2883 – I. Hydrodynamical limit *Monthly Notices of the Royal Astronomical Society* (2008) 387 63-72.
25. de Colle, F., Del Burgo, C., & Raga, A. C.: Diagnostics of inhomogeneous stellar jets. Convolution effects and data reconstruction *Astronomy and Astrophysics* (2008) 485 765 772.
26. Drury, L. O.'C. & Aharonian, F. A.: The puzzling MILAGRO hot spots *Astroparticle Physics* (2008) 29 420-423.
27. Aharonian, Felix A., Khangulyan, D., & Costamante, L.: Formation of hard very high energy gamma-ray spectra of blazars due to internal photon-photon absorption *Monthly Notices of the Royal Astronomical Society* (2008) 387 1206-1214.

28. Covino, S., et al.: The complex light curve of the afterglow of GRB071010A *Monthly Notices of the Royal Astronomical Society* (2008) 388 347-356.
29. Soldi, S., et al.: The multiwavelength variability of 3C 273 *Astronomy and Astrophysics* (2008) 486 411-425.
30. Aharonian, F., et al.: Chandra and HESS observations of the supernova remnant CTB 37B *Astronomy and Astrophysics* (2008) 486 829-836.
31. Kelner, S. R. & Aharonian, F. A.: Energy spectra of gamma rays, electrons, and neutrinos produced at interactions of relativistic protons with low energy radiation *Physical Review D* (2008) 78 034013
32. Garcia Lopez, R., et al.: IR diagnostics of embedded jets: velocity resolved observations of the HH34 and HH1 jets *Astronomy and Astrophysics* (2008) 487 1019-1031.
33. Aharonian, F., et al.: HESS upper limits for Kepler's supernova remnant *Astronomy and Astrophysics* (2008) 488 219-223.
34. Cemeljić, M., et al.: Resistive jet simulations extending radially self-similar magnetohydrodynamic models *Monthly Notices of the Royal Astronomical Society* (2008) 389 1022-1032.
35. Aharonian, F., et al.: High energy astrophysics with ground-based gamma ray detectors *Reports on Progress in Physics* (2008) 71 096901
36. Bosch-Ramon, V., Khangulyan, D., & Aharonian, F. A.: The magnetic field and the location of the TeV emitter in Cygnus X-1 and LS 5039 *Astronomy and Astrophysics* (2008) 489 L21-L24.
37. Tanaka, Takaaki, et al.: Study of Nonthermal Emission from SNR RX J1713.7-3946 with Suzaku *Astrophysical Journal* (2008) 685 988-1004.
38. Covino, S., et al.: The Afterglow Onset for GRB 060418 and GRB 060607A *Chinese Journal of Astronomy and Astrophysics Supplement* (2008) 8 356 360.
39. Aharonian, F., et al.: Limits on an Energy Dependence of the Speed of Light from a Flare of the Active Galaxy PKS 2155-304 *Physical Review Letters* (2008) 101 170402
40. Aharonian, F., et al.: Discovery of a VHE gamma-ray source coincident with the supernova remnant CTB 37A *Astronomy and Astrophysics* (2008) 490 685-693.
41. Piranomonte, S., et al.: The short GRB 070707 afterglow and its very faint host galaxy *Astronomy and Astrophysics* (2008) 491 183-188.
42. Stute, M., et al.: Stability and structure of analytical MHD jet formation models with a finite outer disk radius *Astronomy and Astrophysics* (2008) 491 339-351.
43. Gabici, Stefano, et al.: The diffuse neutrino flux from the inner Galaxy: Constraints from very high energy gamma-ray observations *Astroparticle Physics* (2008) 30 180-185.
44. Piranomonte, S., et al.: Probing the complex environments of GRB host galaxies and intervening systems: high resolution spectroscopy of GRB050922C *Astronomy and Astrophysics* (2008) 492 775-785.
45. Aharonian, F., et al.: Simultaneous HESS and Chandra observations of Sagittarius A' during an X-ray flare *Astronomy and Astrophysics* (2008) 492 L25-L28.
46. De Colle, Fabio, Gracia, Jose, & Murphy, Gareth: The Effect of a Stellar Magnetic Variation on the Jet Velocity *Astrophysical Journal* (2008) 688 1137 1141.
47. De Colle, Fabio, Raga, Alejandro C., & Esquivel, Alejandro: The Dynamics of Internal Working Surfaces in Magnetohydrodynamic Jets *Astrophysical Journal* (2008) 689 302 307.
48. Coffey, Deirdre, Bacciotti, Francesca, & Podio, Linda: T Tauri Jet Physics Resolved Near the Launching Region with the Hubble Space Telescope *Astrophysical Journal* (2008) 689 1112-1126.
49. Aharonian, F., et al.: Energy Spectrum of Cosmic-Ray Electrons at TeV Energies *Physical Review Letters* (2008) 101 261104
50. Whelan, E. T., & Garcia, P.: Spectro-astrometry, the method its limitations and applications, *Lecture Notes in Physics* (2008) 742 123.

SCHOOL OF COSMIC PHYSICS

ASTRONOMY AND ASTROPHYSICS

51. F. Vanhavere, J.L. Genicot, D. OSullivan, D. Zhou, F. Spurny, I. Jadrnickova, G.O. Sawakuchi, E.G. Yukihiro: Dosimetry of Biological Experiments in Space (DOBIES) with luminescence (OSL and TL) and track etch detectors Radiation Measurements, 43 (2008) 694-697.
52. D. Zhou, D. OSullivan, E. Semones, N. Zapp, S. Johnson, M. Weyland: Radiation dosimetry for high LET particles in low Earth orbit Acta Astronautica, 63 (2008) 855 864.

6.2 Non-refereed Publications

These are available online at:

http://adsabs.harvard.edu/cgi-bin/nph-abs_connect?library&libname=NonRef2008&libid=4794ca7845

1. D'Avanzo, P., et al.: GRB 080130: REM NIR observations. GRB Coordinates Network (2008) 7244 1
2. D'Avanzo, P., et al.: GRB 080207: REM NIR observations. GRB Coordinates Network (2008) 7269 1
3. D'Avanzo, P., et al.: GRB 080212: REM NIR afterglow? GRB Coordinates Network (2008) 7302 1
4. D'Avanzo, P., et al.: GRB 080212: REM refined analysis. GRB Coordinates Network (2008) 7310 1
5. D'Avanzo, P., et al.: GRB 080212: VLT optical rapid decay. GRB Coordinates Network (2008) 7311 1
6. Covino, S., et al.: GRB 080218B: REM NIR early upper limits. GRB Coordinates Network (2008) 7322 1
7. D'Avanzo, P., et al.: GRB 080229: REM NIR observations. GRB Coordinates Network (2008) 7342 1
8. D'Avanzo, P., et al.: GRB 080303: REM NIR afterglow candidate. GRB Coordinates Network (2008) 73501
9. Covino, S., et al.: GRB 080310: REM observations. GRB Coordinates Network (2008) 7385 1
10. Covino, S., et al.: GRB 080319B: REM observations. GRB Coordinates Network (2008) 7431 1
11. Covino, S., et al.: GRB 080319A: REM observations. GRB Coordinates Network (2008) 7440 1
12. Covino, S., et al.: GRB 080319B: REM early data. GRB Coordinates Network (2008) 7446 1
13. D'Avanzo, P., et al.: GRB 080330: REM optical observations. GRB Coordinates Network (2008) 75541
14. D'Avanzo, P., et al.: GRB 080309: REM optical/NIR observations. GRB Coordinates Network (2008) 75741
15. Antonelli, L. A., et al.: GRB 080413A: REM detection of the NIR afterglow. GRB Coordinates Network (2008) 75971
16. Antonelli, L. A., et al.: GRB080413B: REM NIR & optical observation. GRB Coordinates Network (2008) 76001
17. Covino, S., et al.: GRB080514: REM NIR & optical observations. GRB Coordinates Network (2008) 77121
18. D'Avanzo, P., et al.: GRB 080710: REM afterglow confirmation & brightening. GRB Coordinates Network (2008) 79601
19. D'Avanzo, P., et al.: GRB 080725: REM prompt observations. GRB Coordinates Network (2008) 80161
20. D'Avanzo, P., et al.: GRB 080727B: REM prompt observations. GRB Coordinates Network (2008) 80231
21. D'Avanzo, P., et al.: GRB 080727B: REM NIR afterglow prompt detection. GRB Coordinates Network (2008) 80371
22. D'Avanzo, P., et al.: GRB 080913: REM NIR early observations. GRB Coordinates Network (2008) 82201
23. Covino, S., et al.: GRB 080915: REM NIR early observations. GRB Coordinates Network (2008) 82331
24. Fugazza, D., et al.: GRB 080916: REM candidate afterglow. GRB Coordinates Network (2008) 82381
25. Antonelli, L. A., et al.: GRB 080916: REM detection of the NIR afterglow. GRB Coordinates Network (2008) 82391
26. Covino, S., et al.: GRB 080919: REM NIR observations. GRB Coordinates Network (2008) 82711

27. Covino, S., et al.: GRB 081007: REM NIR and optical counterpart. GRB Coordinates Network (2008) 83311
28. D'Avanzo, P., et al.: GRB 081017: REM early observations. GRB Coordinates Network (2008) 83891
29. Covino, S., et al.: GRB 081029: REM observations. GRB Coordinates Network (2008) 84411
30. D'Avanzo, P., et al.: GRB 081109: REM NIR afterglow detection. GRB Coordinates Network (2008) 85011
31. Covino, S., et al.: GRB081222: REM candidate afterglow. GRB Coordinates Network (2008) 86921
32. Covino, S., Vergani, S. D., & Malesani, D.: REM observations of the GRB afterglow onset Relativistic Astrophysics (2008) 966 21-24.
33. Tanaka, Takaaki, et al.: Suzaku Observations of SNR RX J1713.7-3946 in the Energy Range from 0.4 Kev up to 40 Kev AAS/High Energy Astrophysics Division (2008)10 38.07
34. Ray, Tom: Generating Jets from Young Stars: An Observational Perspective APS Meeting Abstracts (2008)1
35. Suzuki-Vidal, F., et al.: Formation of Magnetically Driven Radiatively Cooled Plasma Jets in the Laboratory APS Meeting Abstracts (2008)19
36. Reimer, O., et al.: VHE gamma-rays from Westerlund 2 and implications for the inferred energetics Clumping in Hot-Star Winds (2008)195
37. Guidorzi, C. & Vergani, S.: GRB 070311: a common origin for the prompt and afterglow emission American Institute of Physics Conference Series (2008) 1000 417-420.
38. Polcaro, V. F., et al.: Some Considerations on the HMXRB LSI +61 303 Mass Loss from Stars and the Evolution of Stellar Clusters (2008) 388 217
39. Drury, Luke O'c.: Cosmic Rays in Supernova Remnants and the Galaxy American Institute of Physics Conference Series (2008) 1039 427-432.
40. Chernyakova, M., et al.: Latest X-ray observations of PSR B1259-63. American Institute of Physics Conference Series (2008) 1085 215-218.
41. Bosch-Ramon, V., Khangulyan, D., & Aharonian, F. A.: Clues to unveil the emitter in LS 5039: powerful jets vs colliding winds American Institute of Physics Conference Series (2008) 1085 223-225.
42. Gabici, Stefano, Casanova, Sabrina, & Aharonian, Felix A.: Non-thermal radiation from molecular clouds illuminated by cosmic rays from nearby supernova remnants. American Institute of Physics Conference Series (2008) 1085 265-268.
43. Taylor, Andrew, et al.: A reinvestigation into the diffuse neutrino flux from the inner Galaxy in light of new very high energy Γ -ray observations American Institute of Physics Conference Series (2008) 1085 384-388.
44. Casanova, S., et al.: Probing the Galactic cosmic ray flux with submillimeter and gamma ray data American Institute of Physics Conference Series (2008) 1085 389-392.
45. Dempsey, Paul & Kirk, John: Relativistic Shock Acceleration: A Hartree-Fock Approach American Institute of Physics Conference Series (2008) 1085 594-596.
46. Brunetti, G., et al.: Gamma ray emission and stochastic particle acceleration in galaxy clusters American Institute of Physics Conference Series (2008) 1085 628-631.
47. Rieger, Frank M. & Aharonian, Felix: On the Origin of VHE Gamma-Ray Emission in M87 American Institute of Physics Conference Series (2008) 1085 640-643.
48. Costamante, Luigi, et al.: The new surprising behaviour of the two "prototype" blazars PKS 2155-304 and 3C 279 American Institute of Physics Conference Series (2008) 1085 644-647.
49. Aharonian, Felix A., Hofmann, Werner, & Rieger, Frank: VERITAS Blazar Observations-Recent Results American Institute of Physics Conference Series (2008) 1085
50. Aharonian, Felix A., Hofmann, Werner, & Rieger, Frank: VERITAS Blazar Observations-Recent Results American Institute of Physics Conference Series (2008) 1085

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6.3 Preprints

These are available online at:

http://adsabs.harvard.edu/cgi-bin/nph-abs_connect?library&libname=Preprint2008&libid=4794ca7845

1. Zdziarski, A. A., Neronov, A., & Chernyakova, M.: A compact pulsar wind nebula model of the gamma-ray loud binary LS I +61 303 ArXiv e-prints (2008) arXiv:0802.1174
2. Vannoni, G., Gabici, S., & Aharonian, F. A.: Diffusive Shock Acceleration in Radiation Dominated Environments ArXiv e-prints (2008) arXiv:0803.1138
3. D'Elia, V., et al.: The prompt, high resolution spectroscopic view of the "naked-eye" GRB080319B ArXiv e-prints (2008) arXiv:0804.2141
4. Dieckmann, M. E., Meli, A., Shukla, P. K., Drury, L. O. C., & Mastichiadis, A.: Two-dimensional PIC simulations of ion-beam instabilities in Supernova-driven plasma flows ArXiv e-prints (2008) arXiv:0804.2677
5. Bosch-Ramon, V., Khangulyan, D., & Aharonian, F. A.: On the X-ray/TeV connection in Galactic jet sources ArXiv e-prints (2008) arXiv:0805.1700
6. Rieger, F. M. & Aharonian, F. A.: Particle acceleration close to the supermassive black hole horizon: the case of M87 ArXiv e-prints (2008) arXiv:0805.4075
7. Gabici, S., Taylor, A. M., White, R. J., Casanova, S., & Aharonian, F. A.: The diffuse neutrino flux from the inner Galaxy: constraints from very high energy gamma-ray observations ArXiv e-prints (2008) arXiv:0806.2459
8. Coffey, Deirdre, Bacciotti, Francesca, & Podio, Linda: T Tauri Jet Physics Resolved Near The Launching Region with the Hubble Space Telescope ArXiv e-prints (2008) arXiv:0808.0617
9. De Colle, Fabio, Gracia, Jose, & Murphy, Gareth: The effect of a stellar magnetic variation on the jet velocity ArXiv e-prints (2008) arXiv:0808.1949
10. De Colle, Fabio, Raga, Alejandro, & Esquivel, Alejandro: The dynamics of internal working surfaces in MHD jets ArXiv e-prints (2008) arXiv:0808.2346
11. Hinton, J. A., Skilton, J. L., Funk, S., Brucker, J., Aharonian, F. A., Dubus, G., Fiascon, A., Gallant, Y., Hofmann, W., Marcowith, A., & Reimer, O.: HESS J0632+057 : A new gamma-ray binary? ArXiv e-prints (2008) arXiv:0809.0584
12. Stute, Matthias, Tsinganos, Kanaris, Vlahakis, Nektarios, Matsakos, Titos, & Gracia, Jose: Stability and structure of analytical MHD jet formation models with a finite outer disk radius ArXiv e-prints (2008) arXiv:0809.1652
13. Dempsey, Paul & Kirk, John G.: Relativistic Shock Acceleration: A Hartree-Fock Approach ArXiv e-prints (2008) arXiv:0809.2657
14. Khangulyan, D. V., Aharonian, F. A., Bogovalov, S. V., Koldoba, A. V., & Ustyugova, G. V.: Hydrodynamics of interaction of pulsar and stellar winds and its impact on the high energy radiation of binary pulsar systems ArXiv e-prints (2008) arXiv:0809.5197
15. Gabici, Stefano, Casanova, Sabrina, & Aharonian, Felix A.: Non-thermal radiation from molecular clouds illuminated by cosmic rays from nearby supernova remnants ArXiv e-prints (2008) arXiv:0810.0035
16. Henney, William J., Arthur, S. Jane, De Colle, Fabio, & Mellema, Garrelt: Radiation-magnetohydrodynamic simulations of the photoionisation of magnetised globules ArXiv e-prints (2008) arXiv:0810.1531
17. Dionatos, O., Nisini, B., Garcia Lopez, R., Giannini, T., Davis, C. J., Smith, M. D., Ray, T. P., & De Luca, M.: Atomic jets from class 0 sources detected by Spitzer: the case of L1448-C ArXiv e-prints (2008) arXiv:0810.1651
18. Casanova, S., Gabici, S., Aharonian, F. A., Torii, K., Fukui, Y., Onishi, T., Yamamoto, H., & Kawamura, A.: Probing the Galactic cosmic ray flux with submillimeter and gamma ray data ArXiv e-prints (2008) arXiv:0810.4297
19. Bosch-Ramon, Valenti, Khangulyan, Dmitry, & Aharonian, Felix: The TeV emitter structure in LS 5039 ArXiv e-prints (2008) arXiv:0810.4494

20. Taylor, Andrew M. & Aharonian, Felix A.:
The Spectral Shape and Photon Fraction as
Signatures of the GZK-Cutoff ArXiv e-prints (2008)
arXiv:0811.0396
21. O'C. Drury, L., Aharonian, F. A., Malyshev, D., &
Gabici, S.: On the plasma temperature in supernova
remnants with cosmic-ray modified shocks ArXiv
e-prints (2008) arXiv:0811.3566
22. Takahashi, T., Kishishita, T., Uchiyama, Y., Tanaka,
T., Yamaoka, K., Khangulyan, D., Aharonian, F. A.,
Bosch-Ramon, V., & Hinton, J. A.: Study of the
Spectral and Temporal Characteristics of X-Ray
Emission of the Gamma-Ray Binary LS 5039 with
Suzaku ArXiv e-prints (2008) arXiv:0812.3358

6.4 Books and Conference Proceedings

1. Bacciotti, F., Whelan, E. T. & Testi, L. (eds): 2008,
Lecture Notes in Physics, Berlin. Springer Verlag, 742.
2. Aharonian, F. A. & Rieger, F.: "High Energy
Phenomena in Relativistic Outflows", World
Scientific, in press
3. Aharonian, F.A., Hofmann, W. & Rieger, F.: "High
Energy Gamma-ray Astronomy", AIP conference
proceedings, New York, in press

6.5 Theses

Four students successfully defended their PhD theses during the year:

1. Colin Melody Production mechanisms of run-away stars (supervisor E Meurs)
2. Paul Ward, Spectroscopy of gamma-ray bursts (supervisor E Meurs)
3. Susanna Vergani REM studies of gamma-ray bursts (supervisor E Meurs)
4. Anthony Moraghan (Lindsey Scholar, jointly with Armagh Observatory) Numerical studies of protostellar jets (supervisors, M Smyth and T Ray)

In addition Stephane Dudzinski completed his part-time MSc by research with a thesis entitled An Extension to Grid Security Monitoring to incorporate Host-based Intrusion Detection.

7 Invited Talks

• Luke Drury

1. "Theory of Galactic sources and acceleration of cosmic rays", 400th Heraeus Seminar, Physik Zentrum, Bad Honnef, Germany
2. "The National Capability Computing System", IDC conference, Croke Park, Dublin
3. "Particle Acceleration in the Galaxy", 7th International IGGP/SSL conference, Hawaii
4. Two lectures on Particle Acceleration theory at the 2008 Stanford Summer Institute, Stanford, California
5. "What can we learn from XLA about particle acceleration and SNR dynamics", ESF topical workshop on Extreme Laboratory Astrophysics: Advances and Opportunities in High-Energy Density Experiments, Paris
6. "From Cosmochemistry to Astrophysics", 50th Anniversary Festcolloquium of the MPI für kernphysik, Heidelberg

• Felix Aharonian

1. "Theory: general remarks", introductory talk at the workshop "Non-Thermal Hadronic Processes in Galactic Sources", Heidelberg, Germany, January 2008
2. "Supernovae and SNR", conference on "Challenges in Particle Astrophysics", Chateau de Blois, France, May 2008
3. "Theoretical aspects of Very High Energy Gamma Ray Astronomy", APP UK 2008 Conference, Oxford, UK, June 2008
4. "Very High Energy Gamma Ray Astronomy", review talk at the International Seminar "Origin, Mass Composition and Acceleration Mechanisms of UHECRs", Malfa, Salina Island, Italy, September 2008
5. "Status of Gamma Ray Astronomy", 2008 TeV Particle Astrophysics international workshop, Beijing, China, September 2008

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6. "Potential of Ground Based Gamma Ray Astronomy", workshop " Science with the New Generation of High Energy Gamma-Ray Experiments", Padova, Italy, October 2008
7. "TeV astrophysics – highlights", Conference on "High Energy Astrophysics – today and tomorrow", Moscow, Russia, December 2008
8. "High Energy Gamma Ray and Neutrino connections", National Institute for Nuclear and High Energy Physics, Amsterdam, NL, April 11, 2008 (NIKEF colloquium)
9. "The TeV domain of cosmic electromagnetic spectrum", Columbia University, New York, USA, May 5, 2008 (Columbia Physics colloquium)
10. "Very High Energy Gamma-Ray Sources", Princeton Institute for Advanced Study, Princeton, USA, May 6, 2008 (Princeton Astrophysics Seminar)
11. "Cosmology with High Energy Gamma Rays", New York University, New York, USA, May 9 (Astrophysics and Relativity Seminar)
12. Lectures on high-energy processes in relativistic outflows, first La Plata International School on Astronomy, La Plata, Argentina, March
13. Lectures on selected topics in X-and Gamma-ray Astronomy, Pescara International School on Relativistic Astrophysics, December

• Tom Ray

1. "Getting to Grips with the Unknown: How Important are Magnetic Fields in Outflows from Young Stars?" and Conference Summary, Magnetic Fields in the Universe, Conzumel, Mexico, 1st February.
2. "Generating Jets from Young Stars: An Observational Perspective", High Energy Density Laboratory Astrophysics Meeting, American Physical Society, St Louis, 11th April
3. "The James Webb Space Telescope", British Astronomical Association, UCD, Dublin, 6th September

4. "Simulating Jets from Young Stars: What Numbers to Use?", ESF Workshop on High Energy Laboratory Astrophysics, Paris Observatory, Meudon, 22 September

5. "Solving the Stellar Angular Momentum Problem: Do Jets Have a Role?", ETH, Zurich 9th October

• Masha Chernyakova

1. "Gamma-ray loud binary systems", High Energy Astrophysics VIRGO.UA Workshop (1-3 September 2008, Kiev, Ukraine).

• Stefano Gabici

1. "Gamma ray signatures of Ultra High Energy Cosmic Ray sources", The impact of high-energy-astrophysics experiments on cosmological physics, Chicago, October 2008
2. "Gamma ray astronomy", invited review talk, XXI European Cosmic Ray Symposium, Kosice, September 2008
3. "Molecular clouds with CTA", CTA meeting, Barcelona, January 2008
4. "Molecular clouds/supernova remnants interactions", Nonthermal hadronic mechanisms in galactic sources, Heidelberg, January 2008

• Denis O'Sullivan

1. "Radiation experienced by astronauts determined with CR-39 dosimeters using a human phantom on ISS" 59th IAC, Glasgow, UK, Oct. 2008

8 Current Grants

• Luke Drury

1. PRTL-4 e-INIS, Project Coordinator
2. EU Marie Curie fellowship
3. SFI RFP award one postdoc (awaiting sanction to appoint)

• Evert Meurs

1. SFI RFP one postgrad

- **Felix Aharonian**

1. EU FP6 Design Study KM3NeT, 40K, Preparatory Phase 30K
2. SFI RFP, two postgrads
3. IRCSET, one postdoc

- **Tom Ray**

1. EU JETSET, two postdocs and an administrator
2. PRODEX MIRI
3. SFI RFP, one postdoc and one postgrad
4. IRCSET, one postdoc

- **Carlos del Burgo**

1. co-I on proposal of PI Eduardo Martin, project: AYA2007-67458, "DETECCION DE EXOPLANETAS TELURICOS CON ESPECTROGRAFOS DE MUY ALTA RESOLUCION ESPECTRAL EN TELESCOPIOS DE GRAN DIAMETRO" (which means "Detection of exoplanets using high spectral resolution spectrographs in big telescopes") 500K over three years.

- **Denis O'Sullivan (emeritus)**

1. DOBIES – from Enterprise Ireland under PRODEX, 24k over 2 years

9 Proposals Submitted

- **Luke Drury**

1. Joint PI proposal with John Morrison (UCC) and Andy Shearer (NUIG) to SFI for Data-Centric Computing

- **Felix Aharonian**

1. EU FP7 Preparatory Phase KM3NeT, 30K

- **Tom Ray**

1. FP7 MC training Network proposal, JETset-II
2. PRODEX funding for MIRI software development team

10 Community Service etc

- **Luke Drury:**

1. Member of the ICHEC oversight board;
2. Chairman of the interview panel for the NUI travelling studentships;
3. Member of the H.E.S.S. Collaboration Board;
4. Member of the KM3NeT consortium;
5. Member of the RIA Astronomy and Space Science Committee;

- **Felix Aharonian:**

1. co-PI of the ROTSE project;
2. member of the H.E.S.S. Collaboration Board;
3. member of the Consortium of the KM3NeT;
4. member of the working group "Science with NeXT" (Japanese next generation X-ray mission);
5. member ("Principal Scientist/Professor") of the Heidelberg Graduate School of Fundamental Physics at the University of Heidelberg;
6. Adjunct Professor of the International Center for Relativistic Astrophysics Network, Pescara/Rome
7. Course of lectures on radiation process in high energy astrophysics, TCD, February
8. external scientific member of the MPIK in the High Energy Astrophysics Group
9. co-director of LEA -European Associated Laboratory on High Energy Astrophysics (jointly supported by CNRS and MPG);
10. member of the European Astronet Infrastructure Roadmap Panel A: "High energy, astro-particle astrophysics and gravitational waves";
11. member of the International Review Panel of the Helmholtz Association: "Astroparticle Physics"
12. an Editor of the International Journal of Modern Physics D.

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- **Evert Meurs:**

1. member of the REM consortium;
2. member of the RIA Astronomy and Space Science Committee in which capacity he finalised the National Plan for Astronomy in Ireland (2009–2019), which underlines the case for Irish membership of the European Southern Observatory (ESO);
3. member of the Space Strategy Working Group (Space Industry Skillnet);
4. member of the Joint Management Committee, Armagh Observatory and Planetarium.

- **Tom Ray**

1. Co-PI of the MIRI project;
2. Chairman of the e-MERLIN Steering Committee (Steering committee for national radio astronomy facilities in the UK);
3. Adjunct Professorship Trinity College Dublin (from October 2008);
4. External Expert EU Framework 7 Programme;
5. Member of the Herschel Observatory Time Allocation Committee;
6. Member of the Physical and Chemical Sciences Committee, Royal Irish Academy

- **Carlos del Burgo**

1. co-PI of the Nahual project

- **Dennis O'Sullivan**

1. Presented with the Walker medal at the International SSNTD conference in Bologna
2. Elected to membership of the Royal Irish Academy

11 Public Outreach

E.J.A. Meurs gave a talk on The Universe a laboratory of extremes to Hartstown Community School (Dublin 15) fifth and sixth form classes (23 January).

The normal programme of Open Nights concluded in March and recommenced in October. In a welcome development it was supplemented by a growing number of special events for specific interest groups (see Fig 2). In addition the Irish Astronomical Society were facilitated by being allowed the use of Dunsink for their meetings. The total number of visitors to Dunsink continues to rise and is now close to 2000 a year (see Fig 3). The final event of the year was Christmas themed with the presenters and some of the audience wearing santa hats (see Fig 4)!

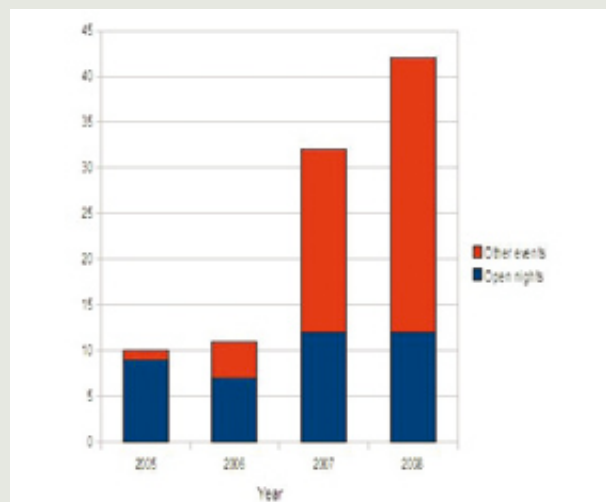


Figure 2: Number of events held in Dunsink by year

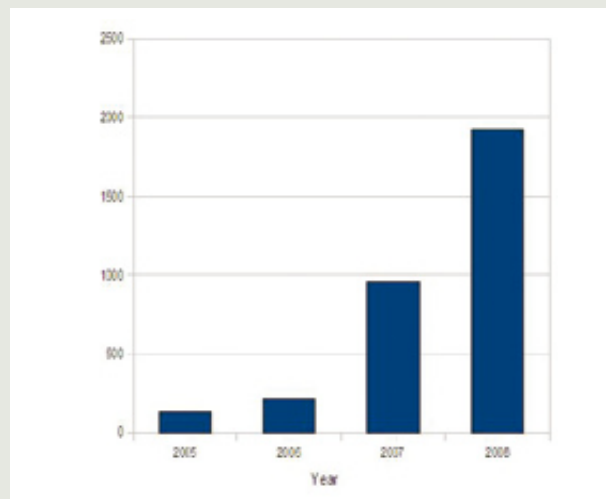


Figure 3: Total number of visitors to Dunsink by year

Date	Event	Time	Principal Speaker
9 Jan	Open Night	19:30	Ian Elliott
21 Jan	IAS meeting	19:30	A McCrea
23 Jan	Open Night	19:30	L Krista (TCD)
30 Jan	Special Event	19:00	W Nahm (DIAS)
5 Feb	University Evening	19:30	M Shadmehri (DCU)
6 Feb	Open Night	19:30	F McGroarty (QUB)
18 Feb	IAS meeting	19:30	M Shadmehri (DCU)
20 Feb	Open night	19:30	A Fitzsimmons (QUB)
27 Feb	University Mature Students	19:30	P Duffy (UCD)
2 Mar	West of Ireland School evening	19:30	M Shamdehri (DCU)
5 Mar	St Columba's Junior School	11:00	E Whelan (DIAS)
5 Mar	Special Event	19:00	D Kelleghan (IAS)
12 Mar	Open night	19:30	T Ray (DIAS)
21 Apr	IAS meeting	19:30	T Hanlon
19 Jun	Noncommutative Geometry conference	14:00	STP
5 Sep	BAA out of town meeting	19:00	E Ansbro
8 Sep	Science & Mathematics Education conference	16:00	M O'Reilly (DCU)
15 Sep	German visitors	19:00	V Witt (MPIA, Heidelberg)
1 Oct	Open night	19:30	T Ray (DIAS)
7 Oct	Danish group	19:30	C del Burgo & C Melody (DIAS)
15 Oct	Open night	19:30	D Kelleghan (IAS)
16 Oct	Hamilton Walk	13:00	NUIM
20 Oct	IAS meeting	19:30	L Drury (DIAS)
23 Oct	Tempelogue special event	19:30	F McGroarty
5 Nov	Open night	19:30	D Malone (NUIM)
Science week 2008			
10 Nov	South Dublin after-school group	16:00	IAS
	Dominican convent	19:00	E Whelan
11 Nov	St Peter's Jr School	13:30	S Delaney et al
	Our Lady's Tempelogue	19:00	P Dempsey
12 Nov	Deansgrange Jr school	11:00	D Kelleghan
	St Paul's Walkinstown	19:00	C Raftery
13 Nov	Educate together	11:00	D Malishev et al
	Loreto Bray	19:00	T Ray
17 Nov	IAS event	19:30	B Harvey
19 Nov	Open night	19:30	C Raftery (TCD)
26 Nov	University evening	19:00	NUIM+TCD
1 Dec	IAS event	19:30	J O'Neill
3 Dec	Open Night	19:30	M Shadmehri (NUIM)
17 Dec	Christmas Event	19:30	E Whelan (DIAS)

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The following assisted regularly in running the above events: Nicola Meenan, Orna Nicholl (TCD students); Denys Malishev, Paul Dawson, Luke Drury, Ann Grace, Eileen Flood, Hilary O'Donnell, Mike Smyth (DIAS); Deirdre Kelleghan, Robin Moore, Val Dunne (IAS).



Figure 4: Christmas in the South dome! Note the red LED lighting of the floor (installed during the year by M Smyth) which has greatly improved safety without affecting night vision

12 Conferences Organised

12.1 JETSET School on "High Performance Computing in Astrophysics"

This JETSET school (the last in the current series) was held from 8th – 13th January in the Astronomy Centre, NUI, Galway and consisted of a series of lectures on computational techniques with applications to astrophysical problems where possible. The school also contained a course on MPI, an introduction to grid technology, lectures on adaptive mesh refinement techniques and sessions on virtual observatories and analysis of large datasets.

Shorter presentations addressed applications of HPC to astrophysical problems such as 3D radiative transfer, large-scale jet simulations and jet stability. During the school, the participants had access to a computer lab to facilitate hands-on exercises. There were also a limited number of contributed oral presentations from the approximately 80 participants.

12.2 PIC Simulations of Relativistic Shocks

This workshop, supported by the Astrosim programme of the ESF, brought together 33 scientists working on the application of modern computing techniques and resources to "particle in cell" simulations of the basic physics of relativistic collisionless shocks. The format was deliberately designed to emphasis the workshop, rather than mini-conference, nature of the meeting with working groups and practical sessions being given as much if not more prominence than standard talks. The support of the Irish Centre for High-End Computing, of Grid-Ireland, and of the computer science department in TCD was essential for this aspect of the programme. All participants shared a common lunch each day (paid for from the ESF grant) which facilitated interaction and informal discussion and prevented the group breaking up and dispersing. Feedback from the meeting has been uniformly positive and a number of joint publications are promised.

The active engagement and hard work of the local organising committee, in particular Hilary O'Donnell (logistics and catering) and Paul Dempsey (web site and coordination) contributed greatly to the smooth running of the meeting.



Group photograph of the participants in the PIC Workshop

12.3 JETSET International Conference “Protostellar Jets in Context”

This conference was held from 7-12 July in Rhodes, Greece. The main goal of this meeting was to review the recent contributions of theoretical and computational modelling, high-resolution observations, and laboratory experiments to our understanding of jets and outflows from young stars. The connection with accretion disks and the similarities with outflow phenomena in other astrophysical contexts was also explored. The conference brought together some 140 scientists working in these various fields to stimulate cross-disciplinary exchange. It contained both invited and contributed talks (many by JETSET postdoctoral fellows), as well as poster sessions. The proceedings will be published by Springer-Verlag and edited by Profs. Kanaris Tsinganos and Tom Ray.



Group photograph of the Rhodes Conference

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1. General

1.1 Personnel Highlights

The personnel highlight of 2008 was the arrival in February of Dr. Sergei Lebedev from Utrecht as the Mallet Assistant Professor of Seismology. Professor Lebedev's 2008 RFP SFI proposal was successful, and he brought on board two new students, Joanne Buckenmayer (France) and Matthew Agius (Malta), and began a search for a Post-Doctoral Fellow.

Another highlight was the arrival of Professor Ben Kennedy, who is the Co-ordinator of the Irish Geoscience Graduate Programme. Professor Kennedy brings a lot of experience to the position, having formerly been Dean of the Faculty of Science at UCD.

Four other students initiated their studies in 2008, David Khoza (South Africa) and Pieter-Ewald Share (South Africa) to work with Professor Alan Jones on SAMTEX data, Eric Mandolesi (Italy) to work with Professor Alan Jones on Joint Inversion of seismic and electromagnetic data for anisotropic structures, and Gulden Polat (Turkey) to work with Professor Peter Readman on the ISUME project. In addition, Dr. Estelle Roux (France) joined Jones's group as a Post-Doctoral Fellow on Joint Inversion of seismic and electromagnetic data for anisotropic structures.

The Section said sad goodbyes to Drs. Max Moorkamp and Anna Avdeeva, both off to the Marine Institute in Kiel, and to Schrödinger Fellow Dr. Xavier Garcia, off to the Marine Institute in Barcelona. However, working relationships with all three are still maintained on a number of projects.

During 2008 the Section initiated the search for the Professor of Geophysics to replace Assistant Professor Peter Readman on his retirement in April, 2009.

1.2 Research Highlights

There were a number of research highlights during 2008.

On the European front, TOPO-EUROPE was launched by the European Science Foundation as a new EUROCORES theme programme, and Jones is a Principle Investigator (PI) of an Individual Project (IP) within one of the accepted Coordinated Research Projects (CRP) under TOPO-EUROPE. TOPO-EUROPE is the largest pan-European

geoscience project ever undertaken, and scientists throughout Europe are involved. More information can be obtained from the ESF web site: <http://www.esf.org/activities/eurocores/programmes/topo-europe.html>

On the international front, the Section continued its involvement with AfricaArray (<http://africaarray.spu.edu/>) through supplying two mentors, David Khoza and Pieter-Ewald Share, to the University of the Witwatersrand for its annual Geophysical Field School, held in June.

Jones and Schrödinger Fellow Dr. Xavier Garcia published a paper on an innovative way of processing noisy high-frequency magnetotelluric data within the so-called audio-magnetotelluric "dead-band" of 1-5 kHz using a robust continuous wavelet transform. This work was initiated whilst Jones and Garcia were at the Geological Survey of Canada in 2000-2001, but was delayed with Jones's move to DIAS and Garcia's move to Woods Hole Oceanographic Institution (WHOI) then DIAS.

The SAMTEX project fulfilled its mission of dense regional magnetotelluric coverage of Southern Africa by completing Phase IV acquisition in Botswana, Namibia and South Africa.

Extensions of the Joint Inversion work by Moorkamp and Jones to deal with including surface wave dispersion data and dealing with anisotropic Earths was initiated.

Lebedev initiated his research activities through successfully obtaining an SFI grant and bringing to the group two new PhD students.

1.3 New External Funding Received in 2008

1.3.1 SFI Proposals Funded:

Section members submitted a total of eight pre-proposals to Science Foundation Ireland's Research Frontiers Programme for the 2008 competition (RFP2008), of which three were invited to proposal stage. Of those three, two were successful

1. A proposal by Jones to continue to work on Tibetan tectonics problems within the INDEPTH (InterNational DEep Profiling of Tibet and the Himalaya) consortium. INDEPTH was started in 1992 in a collaboration between Cornell University and the China Academy of Geological Sciences

(CAGS). Jones came into Phase II of INDEPTH in 1994 when magnetotellurics was added, and has been involved since that time. The proposal was rated as EXCELLENT by all three external reviewers. This project was funded for three years at €196,939, and will support a Post-Doctoral Fellow (2 years) and a Graduate Scholar (3 years).

2. A proposal by Lebedev to understand the dynamics of continental deformation. This was funded for three years at €180,153, and will support a Post-Doctoral Fellow (2 years) and a Graduate Scholar (3 years).

1.3.2 Other Funding Received

Funding provided to Jones by IRCSET for the Topo-Med CRP under the TOPO-EUROPE EUROCORES was for four years at €269,000, and will support a Post-Doctoral Fellow (2 years) and a Graduate Scholar (4 years).

Jones and Lebedev were awarded €15,000 by the European Science Foundation to organize an Exploratory Workshop in 2009 on *DefLAB: Defining the Lithosphere-Asthenosphere Boundary*.

Assistant Professor Brian O'Reilly obtained €90,000 from PIPco/RSG to continue studies of the crustal structure of the Porcupine Region. This funding is to hire a contractor for a year.

Mr. Tom Blake, Experimental Officer in the Section, and Jones received €18,000 from Discover Science and Engineering to launch the *Seismology In Schools* Outreach programme.

1.4 Proposals Submitted

SFI Proposals Submitted to RFP2009 Competition

A total of three (3) proposals were submitted by Section members in September, 2008, to Science Foundation Ireland's Research Frontiers Programme for the Research Frontiers Programme for 2009 (RFP2009).

2. General Geophysics Activities

2.1 CHIGI – Irish Geoscience Graduate Programme

A.G. Jones

In 2007 Jones received an award for €416,000 over a seven year period under the Griffith Geoscience Research Awards scheme administered by the Geological Survey of Ireland on behalf of the Department of Communications, Energy and Natural Resources, for the Irish Geoscience Graduate Programme (IGGP). The IGGP is planned to become a virtual graduate programme for All-Ireland (North and South) within which graduate students will receive advanced training in both specialised and broad-ranging geoscience topics from the academic experts across Ireland. The funding is for a Co-ordinator for the first two years to establish the IGGP, and then an Administrator for the following five years. Professor Ben Kennedy was recruited in the competition held for the Co-ordinator's role, and began his work in May, 2008.

2.2 Qualitative Correlations Between Seismological Observations and Magnetotelluric Ones

A.G. Jones, M. Moorkamp, with S. Fishwick (U. Leicester), D. Eaton (U. Calgary), R. Evans (WHOI).

There are increasingly more and more places where high quality seismological observations can be compared with high quality magnetotelluric data and models. This is leading to a number of statistical comparisons, which suggest a strong coupling between velocity and electrical conductivity in some locations.

Presentations:

Eaton, D.W., F. Darbyshire, R.L. Evans, H. Grutter, **A.G. Jones**, and X. Yuan, 2008. The elusive lithosphere-asthenosphere boundary (LAB). Contributed paper at: EUG 2008, Vienna, 14-18 April.

Jones, A.G., S. Fishwick, and the SAMTEX team, 2008. Comparison of seismic and electrical parameters for the lithosphere of Southern Africa. Contributed paper at: EUG 2008, Vienna, 14-18 April.

Jones, A.G., R.L. Evans, and D.W. Eaton, 2008. Velocity-conductivity relationships for mantle mineral assemblages

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in Archean cratonic lithosphere based on extremal bounds. Contributed paper at: EUG 2008, Vienna, 14-18 April.

Jones, A.G., J. Plomerova, and T. Korja, 2008. Electrical and seismic estimates of the depth to the LAB. Invited Keynote Presentation at: 33rd International Geological Congress, Oslo, Norway, 06-15 August.

Jones, A.G., 2008. Observations of the electrical Moho. Invited Presentation at: 33rd International Geological Congress, Oslo, Norway, 06-15 August.

Cook, F., D. White, **A.G. Jones**, D. Eaton, J. Hall, and R. Clowes, 2008. How the crust meets the mantle: Lithoprobe perspectives on the Moho and crust-mantle transition. Contributed paper at: 33rd International Geological Congress, Oslo, Norway, 06-15 August.

Hamilton, M.P., and **A.G. Jones**, 2008. A new model to explain seismic anisotropy of the upper mantle from SKS studies. Contributed paper at: 33rd International Geological Congress, Oslo, Norway, 06-15 August.

Hamilton, M.P., **A.G. Jones**, **M.R. Muller**, **M.P. Miensopust**, **X. Garcia**, R.L. Evans, P. Cole, T. Ngwisanyi, D. Hutchins, S. Fourie, S. Evans, A. Mountford, W. Pettit, and the SAMTEX, MT Team, 2008. The electrical anisotropy of the continental lithosphere: Methods of analysis and results for southern Africa. Contributed paper at: 33rd International Geological Congress, Oslo, Norway, 06-15 August.

Jones, A.G., J. Plomerova, T. Korja, F. Sodoudi, and W. Spakman, 2008. Geophysical imaging of deep lithospheric structure and the Lithosphere-Asthenosphere Boundary of Europe. Invited Presentation at: 4th TOPO-EUROPE Workshop, El Escorial (Madrid), Spain, 5-8 October.

2.3 Joint Inversion of Electromagnetic and Seismic Data

A.G. Jones, M. Moorkamp, E. Roux, E. Mandolesi, S. Lebedev

Under a short Post-Doctoral Scholarship, Dr. Max Moorkamp continued with the developments and extensions of the Joint Inversion to include Surface Wave (SW) dispersion data together with Receiver Functions (RF) and Magnetotelluric (MT) data. Dr. Moorkamp left for Kiel in February, 2008, but continued to collaborate with Jones and the group.

Dr. Estelle Roux joined DIAS in February, 2008 from IPGP, as an SFI-funded Post-Doctoral Fellow and began work on extending the SW+MT inversion for anisotropic one-dimensional structures. Mr. Eric Mandolesi, an SFI-funded PhD student, started in October, 2008, and his task is to extend the work into two dimensions.

Presentations:

Moorkamp, M., **A.G. Jones**, **S. Lebedev**, S. Fishwick, and The SAMTEX Team, 2008. Joint inversion of receiver functions, surface wave dispersion and magnetotelluric data. Contributed paper at: EUG 2008, Vienna, 14-18 April.

Moorkamp, M., **A.G. Jones**, **S. Lebedev**, S. Fishwick, and E. Roux, 2008. Joint inversion of receiver functions, surface wave dispersion and magnetotelluric data. Contributed paper at: 33rd International Geological Congress, Oslo, Norway, 06-15 August.

Moorkamp, M., **A.G. Jones**, S. Fishwick, **S. Lebedev** and The SAMTEX Team. 2008. Non-linear joint inversion of multiple datasets with a genetic algorithm. Contributed paper at: 19th EM Induction Workshop, Beijing, China, 23-29 October.

Roux, E., **M. Moorkamp**, **A.G. Jones** and **S. Lebedev**, 2008. Joint inversion of magnetotelluric and surface waves data in anisotropic media. Contributed paper at: 19th EM Induction Workshop, Beijing, China, 23-29 October.

Roux, E., **M. Moorkamp**, **A.G. Jones** and **S. Lebedev**, 2008. Joint inversion of magnetotelluric and surface waves data in anisotropic media. Contributed paper at: Fall AGU, San Francisco, U.S.A., 15-19 December 2008

3. Electromagnetic Activities

3.1 SAMTEX (Southern African Magnetotelluric Experiment)

A.G. Jones, X. Garcia, M. Muller, M. Miensopust, D. Khoza, P.-E. Share

The main activity on the SAMTEX project in 2008 was the Phase IV acquisition, which took place in February to April. New data were acquired at some 150 locations in primarily Botswana and Namibia, with also two

short profiles in South Africa. This involved making measurements in the Central Kalahari Game Reserve, an area approx. 75% the size of the island of Ireland but without any logistical support whatsoever and with very testing conditions, such as thick Kalahari sands and dangerous roaming wildlife (lions, hyenas) that required particular attention to logistics and to Health and Safety. Broadband (BBMT) and long period (LMT) magnetotelluric measurements were made at over 150 locations.

Two externally-funded M.Sc. students initiated their research in Summer, 2008, at DIAS. David Khoza is funded by BHP-Billiton, and Pieter-Ewald Share by the South African Council for Scientific and Industrial Research. Mark Hamilton completed his PhD thesis and left for a position in industry.

Presentations:

Jones, A.G., 2008. Archean lithospheric geometries and tectonic processes revealed by electromagnetic imaging. **Invited** seminar, U. Cape Town, South Africa, 11 February.

Jones, A.G., 2008. Insights into Archean processes from deep ElectroMagnetic imaging: Preliminary results from the SAMTEX project. **Invited** seminar, U. Namibia, Windhoek, Namibia, 19 February.

Jones, A.G., 2008. Lithospheric-scale structures and geometries of cratons and their bounding belts in southern Africa from deep-probing electromagnetic studies: Implications for diamond exploration. **Invited** seminar, UCD, Dublin, 31 March.

Jones, A.G., and the SAMTEX team, 2008. Southern African lithospheric geometries deduced from electromagnetic imaging: the SAMTEX project. Contributed paper at: EUG 2008, Vienna, 14-18 April.

Jones, A.G., S. Fishwick, and the SAMTEX team, 2008. Comparison of seismic and electrical parameters for the lithosphere of Southern Africa. Contributed paper at: EUG 2008, Vienna, 14-18 April.

Jones, A.G., M.R. Muller, M.P. Hamilton, M.P. Miensoopust, X. Garcia, R.L. Evans, P. Cole, T. Ngwisanyi, D. Hutchins, S. Fourie, S. Evans, A. Mountford, W. Pettit, and the SAMTEX, MT Team, 2008. The Southern African Magnetotelluric Experiment (SAMTEX) images the

underbelly of southern Africa. Contributed paper at: 33rd International Geological Congress, Oslo, Norway, 06-15 August.

Hamilton, M.P., and **A.G. Jones**, 2008. A new model to explain seismic anisotropy of the upper mantle from SKS studies. Contributed paper at: 33rd International Geological Congress, Oslo, Norway, 06-15 August.

Hamilton, M.P., A.G. Jones, M.R. Muller, M.P. Miensoopust, X. Garcia, R.L. Evans, P. Cole, T. Ngwisanyi, D. Hutchins, S. Fourie, S. Evans, A. Mountford, W. Pettit, and the SAMTEX, MT Team, 2008. The electrical anisotropy of the continental lithosphere: Methods of analysis and results for southern Africa. Contributed paper at: 33rd International Geological Congress, Oslo, Norway, 06-15 August.

Jones, A.G., M.R. Muller, M.P. Hamilton, M.P. Miensoopust, X. Garcia, R.L. Evans, P. Cole, T. Ngwisanyi, D. Hutchins, C.J.S. Fourie, S.F. Evans, A. Mountford, W. Pettit, and the SAMTEX Team, 2008. Area selection using magnetotellurics: Examples from southern Africa. Contributed paper at: 9th International Kimberlite Conference, Frankfurt, Germany, 11-15 August.

Muller, M.R., A.G. Jones, S. Fishwick, C. Hatton, H. Grutter, R.L. Evans, X. Garcia, **M.P. Hamilton, M.P. Miensoopust**, J.E. Spratt, S.F. Evans, A. Mountford, W. Pettit, P. Cole, T. Ngwisanyi, D. Hutchins, C.J.S. Fourie, and the SAMTEX Team, 2008. Diamond prospectivity of the Rehoboth Terrane, southern Africa, based on integrated geophysical and geochemical constraints on its Proterozoic lithospheric structure and evolution. Contributed paper at: 9th International Kimberlite Conference, Frankfurt, Germany, 11-15 August.

Jones, A.G., M.R. Muller, M.P. Hamilton, M.P. Miensoopust, C. Hogg, R.L. Evans, P. Cole, T. Ngwisanyi, D. Hutchins, C.J.S. Fourie, M. Doucoure, A. Mountford, W. Pettit, S. Webb, J. Wasborg, and The SAMTEX Team, 2008. SAMTEX: The electrical lithosphere of Southern Africa. Contributed paper at: 19th EM Induction Workshop, Beijing, China, 23-29 October.

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3.2 PICASSO (Programme to Investigate Convecting Alboran Sea System Overturn) and TopoMed (Plate Re-organization in the Western Mediterranean: Lithospheric Causes and Topographic Consequences)

A.G. Jones, J.-P. Schmoldt

PICASSO (funded by SFI) and TopoMed (funded by IRCSET) are companion projects studying the collision of Africa with Europe as expressed in the western Mediterranean. The focus of PICASSO by the DIAS MT group is primarily Iberia and northern Morocco, whereas the focus of TopoMed is the Atlas Mountains. Both projects have very extensive international partners and linkages, both within Europe and North America (U.S.A. and Canada).

TopoMed ESF web site: <http://www.esf.org/activities/eurocores/running-programmes/topo-europe/the-crps/topomed.htm>

Presentations:

Schmoldt, J.-P., A.G. Jones, C. Hogg and O. Rosell, 2008. PICASSO- Phase I: MT Investigation of the Betic-Rif mountain system. Comparison of actual robust processing algorithms. Contributed paper at: 19th EM Induction Workshop, Beijing, China, 23-29 October.

3.3 3D MT Modelling/Inversion

M. Miensopust and A.G. Jones

Miensopust and Jones initiated a programme of research into comparing three-dimensional magnetotelluric forward codes and testing out available inversion codes. Miensopust visited Dr. Colin Farquharson of the Memorial University of Newfoundland, Canada, during August.

A DIAS workshop on 3D MT Inversion took place as the 2nd St. Patrick's Geophysical Workshop held in Dublin in mid-March prior to St. Patrick's Day. Test models and data were prepared by Miensopust and Jones, together with Professor Pilar Queralt, of the University of Barcelona, who spent three months as a Visiting Scientist to the Section in October to December.

Presentation:

Miensopust, M.P., P. Queralt, and A.G. Jones, 2008. Three-dimensional models for MT code testing: Preliminary results and comparison. Contributed paper at: 31st International Geological Congress, Oslo, Norway, 06-15 August.

Miensopust, M.P., C.G. Farquharson and A.G. Jones, 2008. A finite-element, 3D MT inversion code using local coordinates for each site and solving for distortion parameters. Contributed paper at: 19th EM Induction Workshop, Beijing, China, 23-29 October.

Miensopust, M.P., P. Queralt, A.G. Jones and the 'MT 3D inversion' workshop attendees, 2008. MT 3D inversion – a recapitulation of a successful workshop. Contributed paper at: 19th EM Induction Workshop, Beijing, China, 23-29 October.

Moorkamp, M., M. Belmonte, R.L. Mackie and **M. Miensopust**, 2008. Proposal for a standardized 3D EM model format based on NetCDF. Contributed paper at: 19th EM Induction Workshop, Beijing, China, 23-29 October.

Miensopust, M.P., C.G. Farquharson and A.G. Jones, 2008. MCMT3DID – a finite-element, 3D MT inversion code using local coordinates for each site and solving for distortion parameters. Contributed paper at: Fall AGU, San Francisco, U.S.A., 15-19 December.

3.4 INDEPTH (InterNational DEep Profiling of Tibet and the Himalaya)

A.G. Jones

Under SFI funding from the RFP2008 competition, Jones continued his long-standing involvement in the INDEPTH project. Phase IV acquisition across the Kunlun and Altyn Tagh faults on the northern rim of the Tibetan Plateau is scheduled for 2009.

3.5 LAPIS (La Palma Internal Structure)

A.G. Jones and X. Garcia

A pilot MT survey was undertaken on La Palma in July 2007 to study the potential for catastrophic collapse of the flank of the Cumbre Vieja volcano that is modelled to pose an extreme tsunami hazard for the northern Atlantic.

Presentations:

Garcia, X., A.G. Jones, C. Hogg, J. Schmoldt and J. Spratt. Structure of an unstable, Atlantic Oceanic island volcano (La Palma, Canary Islands) from land magnetotelluric imaging. Contributed paper at: European Geosciences Union meeting, Vienna, Austria, 14-18 April, 2008.

3.6 Other

Other publications and presentations of work by EM group members of the Section are listed below.

Publication:

Garcia, X., and A.G. Jones, 2008. Robust processing of magnetotelluric data in the AMT dead-band using the Continuous Wavelet Transform. *Geophysics*, 73, F223-F234.

Presentation:

Ferguson, I.J., E. Gowan, **A.G. Jones** and J.A. Craven, 2008. Magnetotelluric mapping of Precambrian structures beneath a Phanerozoic Basin: the Superior Boundary Zone, Manitoba, Canada. Contributed paper at: 19th EM Induction Workshop, Beijing, China, 23-29 October.

4. Seismological Activities

4.1 Seismic Study of Cratons: South Africa

S. Lebedev, J. Buckenmeyer

The DIAS-funded, surface-wave study of South Africa was initiated in 2008 and utilizes novel array processing methods applied to existing data. Variations in thermal structure and thickness of the lithosphere and distributions of seismic anisotropy in the crust and upper mantle are being derived from surface-wave measurements. These results provide new information regarding the physical structure and evolution of Precambrian lithosphere.

Presentation:

Boonen, J., **S. Lebedev**, J. Trampert. Seismic structure of Precambrian lithosphere: New constraints from tomography and broadband surface-wave dispersion. European Geosciences Union General Assembly, Vienna, April 2008.

4.2 Continental Deformation: Seismic Imaging

S. Lebedev, M. Agius

The seismic component of the two-pronged, SFI-funded project initiated in 2008 is focussed on structure and deformation in active continental regions. The main study region is Tibet and East Asia. Application of new seismic methods to the abundant available seismic data (permanent and portable broadband networks) is producing new constraints on the structure and evolution of the lithosphere across the plateau and its vicinity. Seismic anisotropy and inferences on the 3-D deformation and flow within the crust and mantle are of particular interest.

Presentations:

Lebedev, S., T. Meier. (Invited). Surface-Wave Anisotropy and Deformation of Continents American Geophysical Union Fall Meeting, San Francisco, December 2008.

Legendre, C., Meier, T., **Lebedev, S.,** Friederich, W. Large-scale Shear Velocity Structure of the Upper Mantle beneath Europe and Surrounding Regions 31st General Assembly of the European Seismological Commission, Crete, September 2008.

Lebedev, S., Upper-mantle discontinuities and gradients: Their origin, seismic expression and geodynamic significance. European Geosciences Union General Assembly, Vienna, April 2008.

4.3 Global Tomography

S. Lebedev, with R. D. van der Hilst (MIT)

Global variations in the seismic shear wave speeds provide essential constraints on the structure and dynamics of the lithosphere and underlying mantle. Research in 2008 resulted in progress both in tomographic imaging methods and in the mapping of the Earth structure.

Presentations:

Y. Qin, Capdeville, Y., Montagner, J.P., **Lebedev, S.,** Beucler, E. SPICE Benchmark for global tomographic methods. European Geosciences Union General Assembly, Vienna, April 2008.

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S. Lebedev, R.D. van der Hilst. Automated Multimode Inversion of surface and S wave forms: global tomography and SEM benchmarking. ORFEUS Waveform Inversion workshop, Utrecht, June 2008.

4.4 The Aegean: Seismic Structure and Deformation

S. Lebedev, in collaboration with B. Endrun, T. Meier, W. Friederich (Ruhr Univ Bochum)

Unlike the nearly rigid oceanic lithospheric plates, continental plates can undergo internal deformation across broad plate-boundary regions. The mechanism of this deformation remains elusive, largely due to the insufficiency of observational constraints on three-dimensional flow at depth. New measurements of Rayleigh-wave dispersion in the Aegean region reveal layered azimuthal anisotropy indicative of distributed deformation within the lithosphere. Across the northern Aegean, fast shear-wave propagation directions in the mantle lithosphere are parallel to the current extension direction at the surface. In the presently non-deforming Cyclades block, anisotropic fabric in the lower crust trends parallel to the direction of extension in the Miocene. These results imply that the region-scale extension observed at the surface is accommodated, at least in part, by continuous, viscous-fluid-like deformation in the lower crust and lithospheric mantle.

Presentations:

Lebedev, S., B. Endrun, T. Meier. Deformation of continental lithosphere: new insight from seismic anisotropy in the Aegean 31st General Assembly of the European Seismological Commission, Crete, September 2008.

Endrun, B., **S. Lebedev**, T. Meier. Evolution of Deformation in the Aegean Continental Lithosphere Deduced from Layered Seismic Anisotropy 31st General Assembly of the European Seismological Commission, Crete, September 2008.

4.5 HADES (Hatton Deep Seismic)

P.W. Readman, B.M. O'Reilly

The seismic modelling results from the transverse line across the Hatton Basin and Hatton Continental Margin (Profiles 1 and 2) were integrated with those from the axial line in the Hatton Basin (Profile 3). Results from the seismic interpretation were integrated with sonic and lithological well-log data from DSDP and ODP boreholes close to, or coincident with, the high resolution Irish National Seabed Survey / Rockall Consortium (comprising the British Geological Survey and the Irish Shelf Petroleum Studies Group) vertical reflection data and the HADES wide-angle seismic profiles. Anne Chabert started work at the National Oceanographic Centre in Southampton and finished a first draft of her thesis.

Presentations:

Chabert, A., Ravaut, C., Readman, P.W., O'Reilly, B.M., Shannon, P.M. Seismic imaging of the crustal and sedimentary structure of the Hatton Basin on the Irish Atlantic margin. International Geological Congress, Oslo, 6-14 August 2008.

4.6 PIMS (Porcupine Irish Margins)

B.M. O'Reilly, P.W. Readman, F. Hauser

Software development for handling the very large dataset was finalised and the processing of wide-angle raw data gathered during the GEOMAR experiment was completed. The data quality was assessed and tests for further processing, e.g. filtering, were performed. Very preliminary interpretations of the land-based seismic sections using the $t^2 - x^2$ method on suspected reflections within the crust and from the crust-mantle boundary were integrated with well constrained seismic models for onshore structure published during the year.

Further work on modelling and interpretation of the data has been concentrated on the Irish continental shelf and the transition into the Porcupine Basin in order to interpolate the onshore structure seawards. The modelling strategy uses a-priori knowledge built up from past DIAS onshore and offshore seismic experiments, i.e. VARNET and RAPIDS 4. A particular focus of the work was the axial line. This part of the work will hopefully delineate the southern extent of the feature known as the Porcupine Arch, interpreted from the results of the

RAPIDS 4 project as exhumed serpentinised mantle. It will also provide crucial information on the sedimentary architecture of a region previously unknown using conventional industrial seismic acquisition techniques.

Concentrated studies of fine structure and anisotropy in the upper part of the continental lithosphere (i.e. the lower crust and upper mantle) beneath southwest Ireland were undertaken and completed. This work involved the analysis of the complex P- and S-wave coda originating from this depth within the lithosphere and by vertical incidence refraction data from the contiguous offshore region. It was constrained by rock physics data from xenoliths sourced from this depth within Ireland and elsewhere. This type of study, combining these various datasets has seldom, if ever, been attempted before due to lack of suitable data and adequate computational power.

The results indicate that the most likely explanation for lower crustal reflectivity and fine structure observed at wide-angle and vertical incidences is that it is related primarily to partial melting, magmatic differentiation and metamorphism of sediments from active (subduction related) continental margin sources during the final stages of the Caledonian orogenic cycle. Results from these studies were submitted for publication in *Geophysical Journal International*.

Proposal:

Proposal submitted by O'Reilly to Science Foundation Ireland's Research Frontiers Programme (RFP 2008) to develop new ideas generated by the PIMS project work, with a focus on stochastic modelling using high-end computational techniques constrained by rock physics, geochemical and geochronological data.

Publications:

Hauser, F., O'Reilly, B.M., Readman, P.W., Daly, J.S. and Van den Berg, R., 2008. Constraints on crustal structure and composition within a continental suture zone from shear-wave wide-angle reflection data and lower crustal xenoliths. *Geophysical Journal International*, doi:10.1111/j.1365-246X.2008.03945.x, **175**, 1254-1272.

O'Reilly, B.M., Hauser, F., Readman, P.W. A seismic study of the fine scale structure of the upper lithosphere within the Irish Caledonides using 1-D full-waveform methods: what can it tell us about crustal formation processes? Submitted to *Geophysical Journal International*.

Presentations:

O'Reilly, B.M., F. Hauser, P.W. Readman, J.S. Daly and R. Van den Berg. Crustal Composition and Growth Processes in Ireland: Joint Constraints from Controlled Source Seismic and Lower Crustal Xenolith Data. 51st Irish Geological Research Meeting, UCD School of Geological Sciences 29th February – 2nd March 2008.

O'Reilly, B.M., F. Hauser, P.W. Readman, J.S. Daly and R. Van den Berg. The Composition of the Earth's Crust within the Irish Caledonides: A Seismic Perspective. 51st Irish Geological Research Meeting, UCD School of Geological Sciences, 29th February – 2nd March 2008.

O'Reilly, B.M., Hauser, F., Readman, P.W. Crustal composition and structure from controlled source seismology and xenolith data in Ireland. Continental Deformation Workshop, Dublin, 13-14 November 2008.

Hauser, F., B.M. O'Reilly, P.W. Readman, J.S. Daly, R. Van den Berg. Constraints on crustal structure and composition within a continental suture zone from shear-wave wide-angle reflection data and lower crustal xenoliths: a case study from SW Ireland. *Geophysical Research Abstracts*, Vol. 10, EGU2008-A-11116, EGU General Assembly 2008.

O'Reilly, B.M. How did the Irish crust grow? Some insights and speculations from seismology. Invited School Seminar, University College Dublin, 10 November 2008.

O'Reilly, B.M. Continental deformation in and around Ireland: insights from seismic studies of petrological structure in the upper lithosphere. Continental Deformation Workshop, Dublin, 13-14 November 2008.

4.7 ISLE (Irish Seismological Lithospheric Experiment)

P.W. Readman, B.M. O'Reilly, with J.P. O'Donnell and E. Daly, NUI Galway

Work was progressed on the joint inversion study of Irish gravity and ISLE seismic data with J.P. O'Donnell, E. Daly (NUI Galway) and C. Tiberi (Université Pierre et Marie Curie-Paris 6). This study focuses on using tomographic techniques to investigate upper mantle structures. A multi-channel cross-correlation algorithm was used to produce a P-wave relative arrival time residual dataset from data recorded by the ISLE network over the period

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September 2003 to November 2006. The analysis has indicated a change from faster to slower residuals ($\sim \pm 0.5$ sec) from north to south across the proposed suture zone, a result previously suggested by results from the VARNET experiment.

Inversion of the travel-time residuals yields a velocity anomaly model which correlates with the available seismic control at crustal depths. It also reveals a high velocity zone running in a direction orthogonal to the previously proposed Iapetus Suture Zone at greater depths within the upper mantle. The relative arrival time residual dataset is being jointly inverted with the long-wavelength GRACE (Gravity Recovery And Climate Experiment) and EMGO8 satellite-derived gravity datasets to further constrain this structure.

In addition, to model the 3-D crustal density structure across Ireland, the onshore DIAS gravity dataset was merged with the offshore free air anomaly gravity dataset derived from sea surface gradient measurements collected during the Geosat Geodetic Mission and the ERS-1 Geodetic Phase. This dataset was subsequently reduced to the complete Bouguer anomaly and inverted to yield a density anomaly model. After synthetic testing, the resultant density model images the spatial extent of major geological features in Ireland, e.g. Caledonian granites and Cenozoic volcanics. This analysis will be refined and hopefully will yield further information on the depth extent of these features.

Publications:

Readman, P.W., Hauser, F., O'Reilly, B.M. and Do, V.C. Crustal anisotropy in southwest Ireland, from analysis of controlled-source shear-wave data. Submitted to *Tectonophysics*.

Presentations:

O'Donnell, J.P., E. Daly, C. Tiberi, **P.W. Readman, B.M. O'Reilly, F. Hauser**, 2008. Joint inversion of seismic and gravity data onshore Ireland. Geophysical Research Abstracts, Vol. 10, EGU2008-A-03228, EGU General Assembly.

Do, V.C., Readman, P.W. and O'Reilly, B.M. Deep-source anisotropy revealed from shear wave SKS splitting measurements from southwest Ireland Continental Deformation Workshop, Dublin, 13-14 November 2008.

Readman, P.W., V.C. Do, F. Hauser, B.M. O'Reilly, 2008. Studies of Seismic Anisotropy in the Irish Crust. 51st Irish Geological Research Meeting, UCD School of Geological Sciences, 29th February – 2nd March.

4.8 ISUME (Irish Seismological Upper Mantle Experiment)

P.W. Readman, B.M. O'Reilly, G. Polat

The ISUME project began in October with the recruitment of a PhD student, and data collection continued with the servicing and redeployment of some of the stations in more strategic positions. Analysis of suitable data gathered since 2006 for further SKS/SKKS splitting analysis was started in the later part of the year.

A detailed study of crustal anisotropy was undertaken and completed using high quality controlled-source shear-wave data. The results of this study indicated that the crustal contribution to the anisotropy was very low, typically less than 2%. Furthermore, there was no definable correlation between the orientation of tectonic fabrics in the upper crust due to orogenesis, and the propagation of shear-wave seismic energy.

The results of the study are consistent with the detailed investigation of fine structure in the Irish lower crust and uppermost mantle carried out as part of the PIMS project. A publication was prepared on the main results and submitted to Tectonophysics.

Presentations:

Hauser, F., Readman, P.W., O'Reilly, B.M. and Do, V.C. Anisotropy in the crust of southwest Ireland from controlled-source shear-wave data. Continental Deformation Workshop, Dublin, 13-14 November 2008.

4.9 NAPSA (North Atlantic Petroleum Systems Assessment Group)

B.M. O'Reilly, and colleagues from Memorial University, Newfoundland and University College Dublin.

The objective of this project is to investigate and compare the crustal structure of the conjugate north Atlantic margin regions of Newfoundland and Ireland using potential field data and innovative modelling techniques. This project will build upon the large amount of experience accumulated in DIAS and UCD. The Irish

– Newfoundland Partnership of the Department of an Táoiseach is involved and provided seed funding to discuss research initiatives and objectives together with the Petroleum Affairs Division of the Department of Communications and Natural Resources._

Presentations:

Welford, J.M., Hall, J. and **O'Reilly, B.M.** Lithospheric density variations and Moho structure of the Irish rifted continental margin from constrained 3-D gravity inversion. Conjugate Margins Conference, Halifax, Nova Scotia, Newfoundland, 13-15 August 2008.

4.10 Geodynamic Modelling

J. Sheehan, B.M. O'Reilly, P.W. Readman with D. Sokoutis, Vrije University, Amsterdam

Detailed analysis and interpretation of the results of analogue modelling conducted during the previous year in Amsterdam and Florence, was completed. A detailed comparative study of "crustal" features observed in the analogue models was undertaken and the results compared with those observed in the natural prototype, i.e. from the RAPIDS 4 experiment in the Porcupine Basin.

A comprehensive series of 2- and 3-D numerical simulations using the computational resources provided by the Cosmogrid Consortium were also undertaken using the GALE (Generalised Arbitrary Lagrangian-Eulerian) numerical code, made available by the Computational Infrastructure for Geodynamics (CIG). During the simulations measured parameters for analogue models were replicated to ensure a valid comparison. The results were seen to be broadly similar, indicating a high consistency between the results from analogue and numerical modelling approaches. These novel results were presented at a workshop on mantle convection at the University of California, Davis.

Calculations incorporating thermal / rheological effects were also carried out successfully during the year. John Sheehan submitted a complete first draft of his thesis in December.

Presentations:

Sheehan, J., O'Reilly, B.M. and Readman, P.W. A comparison between lithospheric scale numerical and analogue models. Advanced numerical modelling of mantle convection and lithospheric dynamics workshop, University of California, Davis, July 9-11.

4.11 Seismic Network and Irish Earthquakes

T. Blake, G. Wallace, C. Horan, L. Collins

The maintenance and development of the Irish National Seismic Network (INSN) continued throughout the year. Initial discussion has occurred with a view to decommissioning the older short period network. The expansion of the facility to receive real-time seismic data from various international seismic stations to the seedlink server in DIAS has continued throughout the year. Data is now received in real-time from Spain Portugal and the United Kingdom. The implementation of seismic data acquisition software Seiscomp3 is currently under review and awaiting evaluation reports from GFZ, to implement its operation in DIAS.

5. Collaboration with Wider Research Community

5.1 Visits to Other Laboratories by Section Members

5.2 Visitors to the Section

- Dr. Alan Chave, Woods Hole Oceanographic Institution, 21-25 March.
- Dr Sarah Bennetti, Irish Marine Institute, 11-12 June.
- Professor Gordon Cooper, The University of the Witwatersrand, 28 January – 4 February.
- Professor Fiona Darbyshire, University de Quebec a Montreal, 25 March – 20 April.
- Dr Rob Evans, Woods Hole Oceanographic Institution, date TBD.
- Dr. Chris Hatton, Consultant to De Beers, date TBD.

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- Dr Keith Lambkin, Senior Scientist Valentia Met Station Caherciveen Co Kerry, 12-13 November.
- J.-P. O'Donnell, NUI Galway, two extended visits during the year.
- Dr. Joachim Ritter, University of Karlsruhe, late February.
- Ms. Sue Webb, The University of the Witwatersrand, date TBD.

5.3 Collaborative Activities by Section Members

5.3.1 National Bodies

- UCD: ISLE, TRIM
- Met Eireann: Valentia (VAL) seismic station

5.3.2 European Bodies

- GFZ (Germany): DSB
- Karlsruhe: ISLE
- UB (Spain): PICASSO, 3D MT inversion

5.3.3 International Bodies

- GSC (Canada): Nechako, Bathurst high-res EM, Churchill deep MT
- UWO (Canada): Joint inversion, seismology
- WHOI (USA): Marine EM, EM processing
- CGS (RSA), GSB (Botswana), GSN (Namibia): SAMTEX
- Wits (RSA): SAMTEX, AfricaArray

6. Seminars/Short Courses/Workshops

6.1 Seminars

FRIDAY, 1st February, 2008, 4pm

Speaker: Xavier Garcia (DIAS)

Title: Part 1: The multidisciplinary Malin Sea experiment
Part 2: LAPIS: The course of the Birigoyo.

WEDNESDAY, 6th February, 2008, 4pm

Speaker: Mark Everett (Texas A&M University)

Title: Electromagnetic imaging of the human-impacted subsurface.

MONDAY, 10th November, 11:15am

Speaker: Michael Becken (GFZ Potsdam)

Title: The electrical conductivity structure between the transitional (near SAFOD) and locked (SE of Cholame) segments of the San Andreas Fault, including the source region of the non-volcanic tremor.

WEDNESDAY, 19th March, 2008, 4pm

Speaker: Colin Farquharson (MUN St. John's, Newfoundland)

Title: Geophysical inversion: representation of the subsurface.

THURSDAY, 27th March, 2008, 4pm

Speaker: Andrew W. Frederiksen (University of Manitoba)

Title: Varying rheology within the continental lithosphere: an example from the Superior Province.

FRIDAY, 13th June, 4pm

Speaker: John O'Conner (VU University Amsterdam)

Title: Testing a new hotspot-plume model for the Hawaiian-Emperor Chain.

MONDAY, 21st, April, 4pm

Speaker: David Eaton (University of Calgary, Canada)

Title: The elusive lithosphere-asthenosphere boundary (LAB) beneath cratons.

FRIDAY, 25th April, 4pm

Speaker: Gabi Laske (UCSD, USA)

Title: The Hawaiian PLUME project.

6.2 Short Courses

Title: **Inverse Theory**

Presenter: Prof. David D. Jackson (UCLA)

When: 16-20 February, 2008.

Title: **Parallel programming**

Presenter: Simon Wong (ICHEC)

When: 5-8 May, 2008.

Title: **Numerical methods**

Presenter: Prof. Colin Farquharson, (Memorial University of Newfoundland)

When: July, 2008.

6.3 Workshops

Title: MT 3D Inversion Workshop

When: 12-14 March, 2008

Where: School of Cosmic Physics, 5 Merrion Square, Dublin 2

Website: <http://www.dias.ie/mt3dinv/Home.html>

Attendees: Approx. 25, including invited experts

Title: Continental Deformation Workshop

When: 13-14 November, 2008

Where: DIAS, 10 Burlington Road, Dublin 4

Website: http://www.dias.ie/continental_deformation/index.htm
<http://www.dias.ie/>

Attendees: 28 from Europe and North America;
4 from Dublin (TCD, UCD),
17 from DIAS

7. Public Outreach

The Seismology in Schools (Seismolaíocht sa Scoil) (SIS) pilot programme roll out began in earnest in 2008. Following the development of a rigorous implementation plan the induction of teachers into the SIS programme around the country continued throughout the year. The facilities to hold these teachers workshops were provided by the six Education Centres in Dublin West, Dun Laoghaire, Cork, Ballina, Wexford and Portlaoise. There were follow-up visits throughout the year to all the schools in the programme to evaluate the effectiveness of the rollout and the extent to which the implementation had progressed in the schools by the teachers. Local factors determine the extent to which the programme can be implemented and issues such as computer availability, existing school eco awareness programmes as it effects power consumption, and staffing issues meant that not all schools have developed to the same level.

The SIS programme received significant publicity as a result of the Sichuan, China Earthquake of May 12th, 2008. This earthquake had a magnitude 7.8 Richter Scale and the associated shock waves were picked up by Scoil Chonglais, Baltinglass, Co Wicklow, who had just joined the Seismology in Schools (Seismolaíocht sa Scoil) (SIS) pilot programme. There was substantial reporting in the national and local print media of the success of the students, their teacher and the school. Participation by DIAS in the BTYSE in the RDS in Jan 2008 in association with GSI to launch International Year of Planet Earth, meant that DIAS was also able to showcase the Seismology in Schools (Seismolaíocht sa Scoil) (SIS) pilot programme to a captive audience of young scientists. This had a significant bearing in increasing public awareness of the programme throughout the schools.

Dias participated in a very successful collaboration with the Geological Survey of Ireland (GSI) at the British Telecom Young Scientist Exhibition in the RDS in Jan 2008. The Geophysics Section assembled a very popular and successful exhibition of earthquake related material which attracted lot of attention for students, print and electronic media and the general public alike.

8. Miscellaneous

T. Blake, Co-ordinator of Seismology in Schools Programme.

A.G. Jones

- Editorial Board, *Earth, Planets & Space*.
- Associate Editor, *Journal of Geophysical Research*.
- Adjunct Professor, Queen's University, Kingston, Ontario, Canada.
- Adjunct Professor, NUI Galway, Ireland.
- Visiting Professor, Trinity College Dublin, Ireland.
- Honourary Professor, University of Leicester, UK.
- Visiting Scientist, Geological Survey of Canada.
- Member, Committee of Heads of Irish Earth Science Institutes (CHIESI).
- Member, Consultative Committee to the Geological Survey of Ireland.

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- Member, Life, Earth and Environmental Sciences committee of the European Science Foundation.

M. Muller

- Honorary Research Associate, University of the Witwatersrand, Johannesburg, South Africa.

B.M. O'Reilly

- Member, Editorial Board, Irish Journal of Earth Sciences.
- Member, Intermargins Steering Committee.
- Invited to Irish National Roundtable event for GTR-H, "Investment in Geothermal Energy", 3 April 2007, Dublin.

P.W. Readman

- Research Associate, UCD.

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1. External Research Funding 2008

EXTERNAL RESEARCH PROGRAMMES FOR THE SCHOOL OF COSMIC PHYSICS	2008
External Income Funded by Irish Government Bodies	
HEA -PRTLl	3,120,201
SFI Funded Programmes	220,712
IRCSET Funded Programmes	113,005
Heritage Council and RIA	–
Irish Schools, Forfas, Enterprise Ireland	33,950
Department of Marine and Natural Resources	59,578
Sub-Total – Irish Government External Income	3,547,446
Other External Income	
European Community	686,511
Industry and Other	147,635
Sub-Total – Other External Income	834,146
Income from External Research Programmes in 2008	4,381,592

1 Report on Research Work

1.1 Work by Senior Professors and Collaborators

1.1.1 Discrete Hirota Equations

(W. Nahm)

The Soviet time work by A. Kirillov and N. Reshetikhin on integrable lattice systems has created a large set of papers (accessible only in Russian or in not quite sufficient translations by others), which by general opinion is very important, obscure and sometimes impenetrable. Often it is impossible to decide what is a conjecture, which results have unpublished proofs, and where a published proof of a result can be found. Usually the best procedure is to take their statements as a guideline, to try to prove results oneself and to care later about their previous history. In the context of the discrete Hirota equations, it turned out that there were no proven results for the discrete Hirota equation on an infinite strip. Apart from the intrinsic interest of this system it has continuum limits like the Toda chain equations on which Senior Professor L. O’Raifeartaigh had worked for many years. Previous work with S. Keegan had resulted in solutions for half of the strip. An extension of this solution gave a birational equivalence of the solution set on the full strip to a well known algebraic variety, which is sufficient for many purposes. It does not give a complete algebraic description or a universally applicable algorithm to produce exact solutions for all time from given initial data, which are expected to exist in integrable systems. Now this has been achieved. The space of all solutions has been proven to be fibred over the quotient of a maximal torus by its Weyl group, with fibres which all are hypersurfaces in an affine space. The full space can be described by three equations with a syzygy in an affine space.

1.1.2 Algebraic K-Theory

(W. Nahm & S. Zwegers)

In the context of conjectures linking algebraic K-theory with integrable quantum field theories and q-hypergeometric series, work has commenced to describe certain groups of algebraic K-theory in terms of equivalence classes of symmetric matrices over the rational numbers. The aim is a theory which unifies the combinatorial techniques for proving equations of Rogers-Ramanujan type and methods coming from physics.

1.1.3 Edge States of Graphene-Like Materials

(M. Leitner & W. Nahm)

The low energy behaviour of graphene is relativistically invariant. This allows to characterize the edge states in terms of boundary states for a quantum field theory of free fermions. These states are tunable, which is essential for applications. It would be very helpful to have a regime with spontaneous edge currents, but there are quantum field theoretical obstructions which make it necessary to have a rather complex system for this phenomenon to occur. The obstructions were calculated and turned out to require a minimum of four free fermions. At present it is unclear, if this can be achieved.

1.1.4 Discrete Feynman Integral

(T.C. Dorlas & E. Thomas)

In 1948 Feynman introduced an alternative formulation of quantum mechanics, writing the unitary evolution operator as an integral over an infinite-dimensional space of paths with complex weights. Since then, many attempts have been made to make mathematical sense of such Feynman path integrals. After a so-called Wick rotation to imaginary time, the weights become positive real numbers and Kac showed that the resulting integrals have a bona fide mathematical meaning in terms of a measure on the space of continuous paths. This has given rise to major developments, both in statistical mechanics and in quantum field theory, to such an extent that much of field theory is now done in this Euclidean domain. In a sense this means that the Feynman integral is defined as an analytic extension of the Feynman-Kac integral. However, this is not very satisfactory, because it does not provide a real answer to the question whether the concept “Feynman integral” makes sense as such. A moderately successful definition of the latter was formulated by Albeverio and Hoegh-Krohn, after an idea of Ito. Their definition is rather elegant, but it has limited applicability, because it can only be defined for a restricted class of potentials. In a collaboration with Erik Thomas (Groningen), it was shown that a completely satisfactory definition is possible in the case of paths on a discrete set. The path integral can then be defined as a proper complex-valued measure on the set of paths, and the Feynman integral is defined for all measurable potentials. Moreover, the measure is concentrated on regular paths, i.e. those which are constant everywhere except at a finite number of points. This work was published in [3].

1.1.5 Quantum Coding

(T.C. Dorlas & C. Morgan)

Together with a Ph.D. student (Ciara Morgan) the classical capacity of two specific examples of quantum channels with long-term memory: a periodic channel and a random memoryless channel, each with branches given by depolarising channels was studied. Using King's theorem for depolarising channels, it was shown that the classical capacity of these channels is equal to their respective product-state capacities. Moreover, it was also shown that in the case of a random memoryless channel, this result extends to arbitrary memoryless branches for which additivity holds. These results are reported in [08-17], to be published in Phys. Rev. A.

1.1.6 Quantum Entanglement

(T.C. Dorlas & A. Ghesquiere)

Together with another Ph.D. student (Anne Guesquiere) a study has been undertaken of the decay of entanglement of two particles, initially in a Gaussian entangled state, due to the interaction with a heat bath. The entanglement entropy of the initial Gaussian state was computed, but then it was found that this was not a good measure of entanglement for mixed states. Therefore, recently the so-called negativity for the initial state was computed. The case of interaction with a heat bath is still in progress.

1.1.7 Bethe Ansatz

(T.C. Dorlas & M. Samsonov)

Together with Dr. Maxim Samsonov, the thermodynamic limit of the six-vertex model was considered. This model is closely related to the Heisenberg chain in that the Bethe Ansatz equations are in fact the same! The difference is that only a restricted set of solutions, namely those corresponding to the ground state of the Heisenberg chain, is relevant for the six-vertex model. So far, two cases have been treated: those where the interaction parameter Δ takes values in the intervals $(0, 1)$ and $(-\infty, -1)$. In the first case, the Bethe-Ansatz equations can be written in a variational form with a functional which is convex. In the other, one can use a Fourier-transformed version of the equations, together with a contraction-mapping argument. Numerically, it seems that this should work in general, but we have not succeeded in this yet. In the mean time the extension of the latter case to the inhomogeneous Heisenberg chain to prove the existence of the so-called "string solutions" has commenced.

1.1.8 The Totally Asymmetric Exclusion Process

(T.C. Dorlas, V.B. Priezzhev & A. Povolotsky)

Together with Prof. Priezzhev (Dubna, Russia) and Dr. Alexander Povolotsky, progress was made with the study of the TASEP. A new model was introduced, which interpolates between the vicious walkers model and the TASEP. Using a fluctuation-dissipation theorem, this allowed the computation of the distribution of the total current in the TASEP model, giving rise to a new type of distribution function, similar to but different from the Tracy-Widom distribution. This work has been submitted for publication: see [08-16].

1.1.9 Lecture Notes on Relative Entropy

(T.C. Dorlas)

A set of lecture notes on "Relative Entropy on $B(H)$ " is being prepared for the Communications of DIAS series. The main idea of these notes is that the most important aspects of quantum relative entropy do not need the technically difficult Tomita Takesaki theory needed in the cases of general Von Neumann algebras. The notes include an extended appendix on operator theory and operator algebras. A chapter on applications has yet to be written.

1.1.10 Fuzzy Physics & Emergent Geometry

(Denjoe O'Connor)

In 2008 after an intensive study of a three matrix model which is a fuzzy regularization of Yang-Mills theory, it was found that the model had an exotic phase transition where fuzzy geometry emerged as the system cooled. In the large matrix size limit and in the low temperature phase, the geometry became classical and describes Yang-Mills theory fluctuating on a background two sphere. However, for sufficiently high temperatures there appears to be no background geometry. This discovery gave impetus towards a new research direction into the study of emergent geometry in matrix models.

The subject is closely related to the exploration of field theory in its matrix regularized form known as "fuzzy field theory". Fuzzy field theories are field theories where the algebra of functions of a manifold is replaced by a suitable matrix algebra, with matrix dimension N , and the Laplace-Beltrami operator by a suitable double commutator Laplacian mapping matrices to matrices of the same dimension. The triple of Matrix algebra, norm $\|F\| = \sqrt{\frac{\text{Tr}(F^\dagger F)}{N}}$ and Laplacian defines the geometry of the fuzzy space.

The “fuzzy approach” provides a regularization of field theory (and hopefully string theory) that is well adapted to the non-perturbative study both commutative and noncommutative field theories including those with chiral fermions. It is also well suited to the study of supersymmetric models as it is possible to truncate the theory to a finite number of degrees of freedom while retaining the exact supersymmetry. The ingredients are then a graded matrix algebra, where the matrix entries now contains both commuting and anti-commuting (or Grassmann) entries and the trace over matrices is replaced a supertrace.

At the level of the classical Euclidean action, the method naturally preserves most of the fundamental symmetries of the theory in question, though these can be broken spontaneously. In recent years a continually increasing number of fuzzy spaces has become available. These include all flag and superflag manifolds as well as a further large class of algebraic varieties.

The new twist is that, when the field theory is of Yang-Mills type, as the parameters of the model are changed the background geometry itself becomes dynamical. This is a phenomenon closely related to that which occurs in $4 - d$ supersymmetric Yang-Mills theory, where at strong coupling the model is best described as a $10 - d$ supergravity theory or the low energy limit of a superstring theory.

1.1.11 Simulation of a Scalar Field on a Fuzzy Sphere.

(F.G. Flores, X. Martin & Denjoe O'Connor)

The ϕ^4 real scalar field theory on a fuzzy sphere is studied numerically. The phase diagram for this model where three distinct phases are known to exist is refined: a uniformly ordered phase, a disordered phase, and a non-uniform ordered phase where the spatial $SO(3)$ symmetry of the round sphere is spontaneously broken and which has no classical equivalent. The three coexistence lines between these phases, which meet at a triple point, are carefully located with particular attention paid to the one between the two ordered phases and the triple point itself. In the neighbourhood of the triple point all phase boundaries are well approximated by straight lines which, surprisingly, have the same scaling. It is argued that unless an additional term is added to enhance the effect of the kinetic term the infinite matrix limit of this model will not correspond to a real scalar field on the commutative sphere or plane.

1.1.12 Matrix Models, Gauge Theory & Emergent Geometry.

(R. Delgadillo-Blando, Denjoe O'Connor & B. Ydri)

Theoretical predictions and Monte Carlo simulations, for a simple three matrix model that exhibits an exotic phase transition are presented. The nature of the transition is very different if approached from the high or low temperature side. The high temperature phase is described by three self interacting random matrices with no background spacetime geometry. As the system cools there is a phase transition in which a classical two-sphere condenses to form the background geometry. The transition has an entropy jump or latent heat, yet the specific heat diverges as the transition is approached from low temperatures. No divergence or evidence of critical fluctuations when the transition is approached from the high temperature phase is found. At sufficiently low temperatures the system is described by small fluctuations, on a background classical two-sphere, of a $U(1)$ gauge field coupled to a massive scalar field. The critical temperature is pushed upwards as the scalar field mass is increased. Once the geometrical phase is well established the specific heat takes the value 1 with the gauge and scalar fields each contributing $1/2$.

1.1.13 Topological Phase Transitions and Holonomies in the Dimer Model.

(C. Nash & Denjoe O'Connor)

In this work it was demonstrated that the classical dimer model defined on a toroidal hexagonal lattice acquires holonomy phases in the thermodynamic limit. When all activities are equal the lattice sizes must be considered mod 6 in which case the finite size corrections to the bulk partition function correspond to a massless Dirac Fermion in the presence of a flat connection with nontrivial holonomy. For general bond activities it was found that the phase transition in this model is a topological one, where the torus degenerates and its modular parameter becomes real at the critical temperature. It is argued that these features are generic to bipartite dimer models and a more general lattice whose continuum partition function is that of a massive Dirac Fermion is presented.

1.1.14 The Zero Temperature Phase Diagram of the Kitaev Model.

(C. Nash & Denjoe O'Connor)

It was shown that the zero temperature phase diagram of the vortex free sector of the Kitaev model is in one to one correspondence with that of the classical dimer model on the same lattice. It was found that the model generically has three distinct phases. On a honeycomb lattice with a 3×3 fundamental domain all three phases are accessible. As the couplings are varied there are two distinct transitions. The new transition is one to a gapped phase that opens up in the interior of the B phase.

1.1.15 An AB Initio Calculation of the Universal Equation of State for the $O(N)$ Model.

(Denjoe O'Connor, J.A. Santiago & C.R. Stephens)

Using an environmentally friendly Renormalization Group an ab initio universal scaling form for the equation of state for the $O(N)$ model, $y=f(x)$, that exhibits all required analyticity properties in the limits $x \rightarrow 0$, $x \rightarrow \infty$ and $x \rightarrow -1$ was derived. Unlike current methodologies based on a phenomenological scaling ansatz the scaling function is derived solely from the underlying Landau-Ginzburg-Wilson Hamiltonian and depends only on the three Wilson functions γ_λ , γ_ϕ and γ_{ϕ^2} which exhibit a nontrivial crossover between the Wilson-Fisher fixed point and the strong coupling fixed point associated with the Goldstone modes on the coexistence curve. Explicit results for $N=2, 3$ and 4 to one-loop order are given and compared with known results.

1.2 Independent Work by Fellows

1.2.1 String Theory

(V. Braun)

Dr. Braun started working at the Institute in September. Research into the numerical analysis of string theory compactifications continued, in particular with regard to the E_8 heterotic string. Work commenced on the orientifold compactifications of Type IIB string theory and its connections with F-theory.

1.2.2 Compatible Algebraic Structures

(V. Dotsenko)

The notion of compatible algebraic structures appeared implicitly for Lie algebras in works of Magri on integrable systems (his approach to integrability was based on two compatible Poisson brackets). Recently, purely algebraic properties of compatible algebraic structures were studied in several works, e.g. Odesskii-Sokolov (2005) for simple finite dimensional compatible associative algebras, Dotsenko-Khoroshkin (2006) for free algebras with compatible Lie brackets, Strohmayer (2007) for free compatible pre-Lie algebras. It would be interesting to obtain general theorems on free algebras with two compatible O -structures for a given operad O . In [08-19] free compatible associative algebras were described. It turns out that they can be interpreted as certain extensions of well known Hopf algebras of planar rooted trees invented by Grossman and Larson.

1.2.3 Lattice Vertex Operators

(V. Dotsenko)

In [08-20] a conjectural deformation of certain vector spaces associated to Hilbert schemes of points in the plane was obtained. The family of vector spaces that was constructed using representation theory of lattice vertex operator algebras gives a new realisation of a remarkable series of representations of symmetric groups, the so called parking function modules.

1.2.4 Operads and Koszul Duality

(V. Dotsenko & A. Khoroshkin)

Operads, being originally invented by topologists, are used a lot nowadays to study various properties of algebraic structures. Some important methods in operad theory are consequences of Koszul duality for operads. It is quite important to know whether or not an operad is Koszul, and to be able to construct its free resolution. Currently work, with Dr. A. Khoroshkin (ETH Zürich), on some new criteria of Koszulness, and on methods for obtaining free resolutions of general operads is being pursued.

1.2.5 Yang-Mills Theory.

(V. Filev)

The holographic study of strongly coupled flavoured Yang-Mills theories was the main focus of research. The study employs the generalized AdS/CFT correspondence, where a flavour brane is introduced to the gravitational background dual to the pure Yang-Mills theory. The phase diagram of the theory as well as the description of the light meson spectrum was studied.

Ongoing research is dedicated to the holographic description of magnetic catalysis of mass generation in various dimensions. In particular the Dp/Dq systems T-dual to the D3/D7 intersection was looked at. Preliminary results confirmed the expectations based on non-perturbative field theory techniques in D space-times dimensions that the low energy dynamics of the fundamental degrees of freedom was essentially D-2 dimensional, due to the external magnetic field and that there was a dynamical mass generation. The pseudo-Goldstone modes corresponding to the spontaneously broken global symmetries was also studied, with emphasis on the D3/D7 and the D3/D5 systems.

1.2.6 Quantum Field Theory

(B. Qureshi)

Research was focused on noncommutative quantum field theories and the role of quantum groups in these theories. Work was pursued on various applications of non-commutative field theories such as in cosmology and black hole physics. A new approach to noncommutative gauge theories based on the idea of Hopf symmetries was also developed.

1.2.7 Study of Stochastic Systems of Interacting Particles.

(A. Povolotsky)

A model of semi-vicious walkers, which interpolates between the totally asymmetric simple exclusion process and the vicious walkers model, having the two as limiting cases was proposed. For this model the asymptotics of the survival probability for m particles were calculated and a scaling function, which describes the transition from one limiting case to another was obtained. Then, using a fluctuation-dissipation relation it was possible to reinterpret the result as the particle current generating function in the totally asymmetric simple exclusion process.

The particle current distribution asymptotically in the large time limit as the number of particles is fixed was obtained. The results apply to the large deviation scale as well as to the diffusive scale. In the latter a new universal distribution, which has a skew non-Gaussian form was obtained. For m particles its asymptotic behavior is shown to be.

$$e^{-\frac{y^2}{2m^2}} \text{ as } y \rightarrow -\infty \text{ and } e^{-\frac{y^2}{2m}} y^{-\frac{m(m-1)}{2}} \text{ as } y \rightarrow \infty.$$

1.2.8 Exact Renormalization Group

(O. Rosten)

Research during 2008 has involved applying the Exact Renormalization Group (ERG)-which is essentially the continuous version of Wilson's RG-to obtain new and exact nonperturbative results in a variety of field theories.

In the context of quantum electrodynamics (QED), it was demonstrated that, given the definition of the coupling implied by a manifestly gauge invariant ERG, the β -function is free of nonperturbative contributions and thus can be expected to be re-summable.

Following this, it was possible to use the non-renormalization theorem and Pohlmeyer's theorem to argue that there are no non-trivial fixed-points in theories of a scalar, chiral superfield with non-negative anomalous dimension.

The next piece of work was a real watershed for the techniques developed. Using the ERG, it was shown that there are no physically acceptable non-trivial fixed-points in scalar field theory in four or more dimensions. This rules out an asymptotic safety scenario for this theory, and so confirms its triviality. (The analysis was also extended to noncompact, pure Abelian gauge theory.)

The final piece of work drew together strands from the above three. First, an exact renormalization group for theories of a scalar chiral superfield, directly in four dimensional Euclidean space was formulated. By constructing a projector which isolates the superpotential from the full Wilsonian effective action, it turns out that the nonperturbative nonrenormalization theorem follows, quite simply, from the flow equation. Next, it was proven that there are no physically acceptable non-trivial fixed points. Finally, the Wess-Zumino model was considered, as a low energy effective theory. Following an evaluation of the one and two loop beta-function coefficients, it was shown that the beta-function in the massless case does not receive any nonperturbative power corrections.

1.2.9 Condensed Matter Physics

(J. Slingerland)

Topological phases in condensed matter physics and their application to topological quantum computation, as well as topological excitations in gauge theories at high energies (notably monopoles) were studied.

1.2.10 Quantum Hall Effect in the Second Landau Level

(J. Slingerland & P. Bonderson)

With Dr. P. Bonderson (Microsoft), a new physical explanation of conductance plateaus in fractional quantum Hall systems in the second Landau level was proposed, resulting in trial wave functions for the electronic ground states of all observed conductance plateaus in this Landau level, as well as predicting others which may emerge with better sample quality and lower temperatures [11]. A further preprint reporting on a numerical study of the state proposed for filling fraction $12/5$, coauthored with G. Möller (Cambridge), A. Feiguin (Microsoft) and P. Bonderson, is forthcoming.

1.2.11 Theory of Anyon Models

(J. Slingerland, P. Bonderson, E. Ardonne, G.K. Brennan, S. Iblisdir & J.K. Pachos)

Work on a catalogue of anyon models (unitary braided tensor categories) as well as more general unitary tensor categories with up to 6 objects continued and a preprint with P. Bonderson is in preparation. This should be of interest to physicists working on topological systems, especially for the application to topological quantum computation, which requires the detailed data on braiding and tensor recoupling, which has been calculated using software developed for this purpose. It should also interest mathematicians as a source of (counter)-examples in the theory of tensor categories. A paper on specific anyon models associated with the compact Lie groups of rank 2 is also in preparation, in collaboration with E. Ardonne (Nordita). $3j$ -coefficients and $6j$ -coefficients for the quantum groups associated with these models have been calculated. A study of quantum non-locality in anyon models resulted in a preprint with G.K. Brennan (Macquarie University), S. Iblisdir (Universitat de Barcelona) and J.K. Pachos (University of Leeds) [08-13]. It reports on an investigation of the violation of Bell inequalities for topologically protected observables.

1.2.12 Transitions and Edges between Topological Phases

(J. Slingerland, F.A. Bais & S.M. Haker)

With F.A. Bais (University of Amsterdam), work continued on the characterisation of phase transitions between topological phases induced by the condensation of bosonic quasiparticles. This has led to a publication next year in Physical Review B, explaining the general theory and showing connections with constructions in conformal field theory such as the coset construction and the conformal embedding. A further recent preprint with F.A. Bais and S.M. Haaker focuses on the description of boundaries between regions supporting different topological phases that occur in fractional quantum Hall systems and spin lattice models [08-21]. Another preprint describing the relation with the Haldane Halperin hierarchy in the fractional quantum Hall effect is in preparation.

1.2.13 Lattice Models with Topological Phases

(J. Slingerland, J. Vala & J.K. Pachos)

With the groups of J. Vala in Maynooth and of J.K. Pachos in Leeds, Kitaev's spin model on the honeycomb lattice, a soluble model exhibiting two topological phases, one with Abelian and one with non-Abelian anyonic excitations was investigated. It was shown how the symmetry structure of the model allows for a systematic treatment of the perturbation series in the Abelian phase. It was also shown that fermionic excitations which may be moved without energy cost exist throughout the phase diagram. This has resulted in the following publication. [10]. A preprint currently in preparation with Drs. Kells and Vala will describe a new method to solve this model without the introduction of non-physical degrees of freedom (this was necessary in earlier solution methods).

1.2.14 Magnetic Monopoles and Duality

(J. Slingerland, F.A. Bais, L. Kampmeijer & B.J. Schroers)

With Prof. F.A. Bais and Dr. L. Kampmeijer (University of Amsterdam) and Dr. B.J. Schroers (Heriot-Watt University), magnetic monopoles in gauge theories where the gauge group is broken to a residual non-Abelian group were studied. They identified a set of fundamental monopole charges such that all monopoles can be seen as smooth deformations of monopoles that are constructed by patching together spatially separated fundamental monopoles. This is to be published next year. Further work [08-14] concentrated on finding the maximal

symmetry group that is manifest in all phases of these gauge theories and on examining the representation theory of this 'skeleton group' and its implications for the spectrum and fusion of monopoles and dyons.

1.3 Independent Work by Research Scholars and Students

1.3.1 Scattering of δ -Interacting Particles in One Dimension.

(P. Abramski)

A system of n particles interacting via δ -function repulsive potential is considered in one dimension. The scattering of particles by solving the stationary Schrödinger equation for the wave function of the system was described. Two approaches to the problem were used. The first approach was based on the representation of the wave function as a system of waves reflected and transmitted by the domain boundaries. Each domain represents a particular order of numbered particles, while the boundary corresponds to an elementary transposition of two particles. For each pair of neighbouring particles reflection corresponds to the interchange of particle momentums and transmitting is in correspondence with the interchange of particles relative position. It was assumed that the incoming wave has particular unit normalisation either in incoming or outgoing domain. A universal formula was obtained for the wave function in an arbitrary domain for the case of 3 particles and with generalization to n -particle case. For the case of 3 particles clear geometrical interpretation of this result in the form of diagrams with the system of reflected and transmitted waves for each of 6 regions represented all possible relative positions. The completeness of a system of wave functions is equivalent to the condition that any function $f \in L_2(k_1, \dots, k_n)$ orthogonal to all wave functions is identically zero, where k_1, \dots, k_n are the momentums of n particles. Another approach is to use simple regular potentials, e.g. square-well potential, to approximate δ -potential. This approximation should preserve such a property of the scattering operator as unitarity, which it is hoped will be useful for proving completeness in the case of δ -interaction. Unitarity was proved for three domain regions in the problem with two potential barriers of such potential. The same unitarity property of the scattering operator for the case of combination of repulsive square-well potentials i.e for non-negative step-function potential is expected.

1.3.2 Superconformal Quantum Field Theory

(F.A.H. Dolan)

With Prof. H. Osborn, DAMTP, Cambridge, a paper 'Applications of the Superconformal Index for Protected Operators and q-Hypergeometric Identities to $N=1$ Dual Theories' where it was shown matching of the superconformal index of Romelsberger for $N=1$ superconformal theories related by Seiberg and Kutasov-Schwimmer dualities for certain large rank gauge groups was completed. For Seiberg dual theories, matching of the index for finite rank gauge groups using certain elliptic hypergeometric integral identities was shown. Since then, the work has lead to new dual theories and new elliptic hypergeometric integral identities being proposed by Spiridonov and Vartanov. More generally, it is hoped that these ideas can provide for an alternative organising principle for finding dual super-conformal quantum field theories and also lead to deeper algebraic principles behind elliptic hypergeometric integral identities.

1.3.3 Quantum Information

(A. Ghesquire)

In order to better understand loss of coherence in open quantum systems, the entanglement of a Gaussian two-particles system was studied. Firstly using first moments, the system's density matrix was diagonalised and the Von Neumann entropy and the negativity calculated. Then, the system was left to evolve as a closed system, in order to verify that the system's entanglement is time-invariant. Since the entanglement measure resulting from the study of first moments was not a sufficiently satisfactory estimation of a system's entanglement, the study diverged to that of the system's covariance matrix. The state is then left to evolve within an environment, using the non-rotating wave master equation and the entanglement of the remaining state calculated using the same methods as for the $t=0$ case.

1.3.4 Quantum Information Theory

(C. Morgan)

Using product-state encoding, i.e. when a message is encoded into a tensor product of n quantum states on a finite-dimensional Hilbert space H , this state can then be transmitted over a quantum channel given by a completely positive trace-preserving map (CPT) $\Phi^{(n)}$ on $B(H^{\otimes n})$. The associated capacity is known as the product-state capacity of the channel. If $\Phi^{(n)} = \Phi^{\otimes n}$ is a memoryless channel, then the product-state capacity is given by the supremum of the Holevo χ -quantity, evaluated over all possible input state ensembles. This is also known as the Holevo capacity $\chi^*(\Phi)$ of the channel.

On the other hand, a block of input states could be permitted to be entangled over n channel uses. The classical capacity is defined as the limit of the capacity for such n -fold entangled states divided by n , as n tends to infinity. If the Holevo capacity of a memoryless channel is additive, then it is equal to the classical capacity of that channel and there is no advantage to using entangled input state codewords. Although the classical capacity of certain memory-less channels has been shown, the additivity conjecture for the Holevo capacity of most classes of memoryless channel remains open.

Two special cases of a quantum channel with Markovian correlated noise were considered, that is, a periodic channel with depolarizing channel branches and a convex combination of memoryless channels. It was proven that the corresponding capacities are additive in the sense that they are equal to the product-state capacities. In the case of a convex combination of depolarizing channels the proof provided can be extended to other quantum channels whose classical capacity has been proved to be additive in the memoryless case.

1.3.5 Mathematical Analysis of the Spin Chain and Vertex Models.

(M. Samsonov)

Investigation of the Bethe-Ansatz equations for the six-vertex model was carried out. These equations allow two methods of study for different areas of Δ – the anisotropy parameter. One is a variational method and the other is a Fixed Point Method (FPM). Proof for the existence and uniqueness of the solution to these equations for $\lambda > \lambda_0$, where $\lambda = -\cosh(\lambda)$ was given. Currently work on improving this bound is being carried out and also work on the study of the equations for $0 < \lambda < \lambda_0$ is being pursued. In addition work on the Takahashi equations for real parts of strings was carried out. Work on proving the existence and uniqueness theorem for these equations by the same FPM is progressing.

1.4 Work by Research Associates

1.4.1 The Quantum Hall Effect

(B. Dolan & Cliff Burgess)

An ongoing collaboration with Cliff Burgess of the Perimeter Institute, Waterloo, Canada and McMaster University, Hamilton, Ontario, Canada on duality and the modular group in the quantum Hall effect was continued. The role of the modular group in quantum Hall systems consisting of more than one components, such as bi-layers, spin degenerate monolayers and graphene is currently being developed. There is a prediction for a hierarchical structure for the fractional quantum Hall effect in graphene that it is hoped will be tested experimentally in the near future.

1.4.2 Non-Commutative Geometry

(B. Dolan, A. Balachandran, C Nash, D. O'Connor, P. Presnajder, A. Stern, K. Gupta & R. Szabo)

A programme to develop closed matrix algebras approximating compact manifolds, one aim of which is numerical computation, has continued and been extended to cover complex quadrics. A concise formulation of line and spinor bundles over fuzzy CP^n has been developed. The analysis is being further extended to supersymmetric matrix algebras, focusing at the moment on the supersymmetric fuzzy sphere.

In 2008, during a one month visit to Heriot-Watt University in Edinburgh, a new research programme in collaboration with R. Szabo on equivariant dimensional reduction, using fuzzy spaces as internal spaces was initiated. The details of some models with fuzzy S^2 as the internal space was worked out and currently work on extending this to fuzzy CP^2 is being pursued.

1.4.3 Higher Dimensional Field Theories

(D.H. Tchrakian)

Research was concentrated on the following areas of research: Gauge fields in all spacetime dimensions and their topologically stable solutions. This includes both Abelian and non-Abelian gauge fields interacting with gravity, or Higgs fields, or various sigma model fields.

1.4.4 Yang–Mills–Higgs Systems in All Dimensions

(D.H. Tchrakian)

This is a longstanding project. During 2008 the Singular Dirac–Yang configurations were studied with a view to application to D-branes.

1.4.5 Solitons in Sigma and Goldstone Models in All Dimensions

(D.H. Tchrakian)

Gauged and ungauged versions of these models are also a longstanding project. The ungauged versions serve in practice as easy prototypes for the construction of axial and multi-azimutally symmetric solutions. The gauged versions are expected to have more interesting applications. The ungauged Sigma models in particular can have closed form solutions in some cases, which will be used in the numerical construction of multiazimutally symmetric solutions. The triazimutally symmetric case in $D = 7$ will be the first example of a 3D boundary value problem.

1.4.6 Gravitating Yang–Mills

(D.H. Tchrakian)

This is another longstanding project. Field configurations with spherical symmetry in spacetime dimensions $d = 4p$, in the Euclidean regime have been classified. In the Minkowskian case generic static and spherically symmetric solutions in all dimensions have been constructed. The next problem ongoing is the construction of the axially symmetric solutions.

1.4.7 Non-Abelian Field Configurations with Gauge Group $SO(D + 2)$ on R^D

(D.H. Tchrakian)

This is a relatively new project. Such solutions are expected to be unstable (sphaleron like). To date the Higgs model for $D = 2$ with Chern–Simons dynamics has been constructed, and work on including the Yang–Mills term is in progress. The ultimate aim is to go to $D \geq 4$ dimensions, in which case this setup is necessary for the application of non-Abelian Chern–Simons dynamics. (There is some relevance to AdS/CFT models here.)

1.4.8 The Study of Non-Abelian Fields on AdS Spaces with Minkowskian Boundary

(D.H. Tchrakian)

These present an example of YM systems featuring a non-Abelian connection with nonvanishing electric component, and result in a condensate on the boundary, relevant to the boundary theory in the context of AdS/CFT.

1.4.9 Construction of Gravitating Yang–Mills–Higgs Solutions

(D.H. Tchrakian)

This is a longstanding project. It enables the description of a system featuring a Non-Abelian connection with nonvanishing electric component, without recourse to spaces with Minkowskian boundary. The $d = 4p$ and $d = 4p + 2$ examples are analysed, and the next step is to proceed to the case of odd d .

2 Publications

2.1 Communications of the Dublin Institute for Advanced Studies, Series A.

2.2 Papers in Refereed Journals

- [1] T.C. Dorlas & C. Morgan: Calculating a maximizer for quantum mutual information. *International Journal of Quantum Information* **6** (2008) 745–750.
- [2] T.C. Dorlas & W. Skrypnik: Three order parameters in quantum XZ spin-oscillator models with Gibbsian ground states. *Symmetry, Integrability and Geometry: Methods and Applications (SIGMA)* **4** (2008) 007.
- [3] T.C. Dorlas & E.G.F. Thomas: The discrete Feynman integral. *J. Math. Phys.* **49** (2008) 092101.
- [4] S. Adams & T.C. Dorlas: Asymptotic Feynman–Kac formulae for large symmetrised systems of random walks. *Ann. de l’Inst. H. Poincaré* **44** (2008) 837–875.
- [5] F.A. Dolan: Counting BPS operators in $N = 4$ SYM. *Nucl. Phys. B* **790** (2008) 432.

- [6] B. Dolan, I. Huet, S. Murray & D. O'Connor: A universal Dirac operator and noncommutative spin bundles over fuzzy complex projective spaces. *JHEP* **03** (2008) 029.
- [7] V.G. Filev & C.V. Johnson: Universality in the large N_c dynamics of flavour: thermal vs. quantum induced phase transitions. *JHEP* **0810** (2008) 058.
- [8] T. Albash, V.G. Filev, C.V. Johnson & A. Kundu: Global currents, phase transitions and chiral symmetry breaking in large N_c gauge theory. *JHEP* **0812** (2008) 033.
- [9] O. Rosten: A resumable β -function for massless QED. *Phys. Lett. B* **662** (2008) 237.
- [10] G. Kells, A. T. Bölükbaşı, V. Lahtinen, J.K. Slingerland, J.K. Pachos & J. Vala: Topological degeneracy and vortex dynamics in the Kitaev honeycomb model. *Phys. Rev. Lett.* **101** (2008) 240404.
- [11] P. Bonderson & J.K. Slingerland: Fractional quantum Hall hierarchy and the second Landau level. *Phys. Rev. B* **78** (2008) 125323.
- [12] P. Bonderson, K. Shtengel & J.K. Slingerland: Interferometry of non-Abelian Anyons. *Annals of Physics* **323** (2008) 2709-2755.
- [13] M. Leitner: Zero field Hall effect in $(2 + 1)$ -dimensional QED. *Adv. Theor. Math. Phys.* **12** (2008) 479-491.
- [14] Y. Brihaye, J. Burzlaff & D.H. Tchrakian: Asymptotic analysis of the Skyrmed monopole. *Phys. Rev. D* **77** (2008) 107701.
- [15] E. Radu & D.H. Tchrakian: Goldstone models in $D + 1$ dimensions, $D = 3, 4, 5$, supporting stable and zero topological charge solutions. *J. Phys. A* **40** (2007) 10129-10153.
- [16] E. Radu, D.H. Tchrakian & Y. Yang: Spherically symmetric selfdual Yang-Mills instantons on curved backgrounds in all even dimensions. *Phys. Rev. D* **77** (2008) 044017.
- [17] E. Akofo, A.P. Balachandran, S.G. Jo, A. Joseph & B.A. Qureshi: Direction-Dependent CMB Power Spectrum and Statistical Anisotropy from Non-commutative Geometry. *JHEP* **0805** (2008) 092.

- [18] J. Medina, W. Bietenholz & D. O'Connor: Probing the fuzzy sphere regularisation in simulations of the $3d\lambda\phi^4$ model. *JHEP* **0804** (2008) 041.
- [19] R. Delgadillo-Blando, D. O'Connor and B. Ydri: Geometry in transition: A model of emergent geometry. *Phys. Rev. Lett.* **100** (2008) 201601.

2.3 Papers in Conference Proceedings

- [20] N. Datta, T.C. Dorlas & Y. Suhov: Entanglement-assisted classical capacity for a class of channels with long-term memory. *Quant. Inf. Proc.* **7** (2008).
- [21] B. Dolan, K.S. Gupta & A. Stern: Non-commutativity and quantum structure of space- time. *Fourth International Workshop on Decoherence, Information, Complexity and Entropy, DICE2008, Castello Pasquini/ Castiglioncello (Tuscany), September 22-26, 2008.*
- [22] T. Tchrakian: Dirac-Yang monopoles in all dimensions and their regular counterparts. *Phys. Atom. Nucl.* **71** (2008) 1116-1122.
- [23] A.P. Balachandran and B.A. Qureshi: Twisted statistics of quantum fields on the Moyal plane. *J. Phys.: Conf. Ser.* **103** (2008) 012013.

2.4 Theses and other publications

- [24] Idrish Heut Hernandez: Laplacians and Dirac Operators on CP FN . *Ph.D. Thesis, April 2008, Cinvestav, Mexico.*
- [25] Rodrigo Delgadillo Blando: Matrix Models: A model of Emergent Geometry and Gauge Theory. *Ph.D. Thesis April 2008, Cinvestav, Mexico.*
- [26] Fernando Garcia Flores: Simulations of a Scalar Field Theory on a Fuzzy Sphere. *Ph.D. Thesis April 2008, Cinvestav, Mexico.*
- [27] Seán Murry: Fuzzy Spaces and Vector Bundles. *Ph.D. Thesis, April 2008, NUIM, Maynooth, Ireland.*

2.5 Preprints

DIAS-STP

- [08-01] O. Rosten: A resumable β -function for massless QED.
- [08-02] F. Dolan & H. Osborn: Applications of the superconformal index for protected operators and q -hypergeometric identities to $N=1$ dual theories.
- [08-03] T.C. Dorlas & C. Morgan: Calculating a maximizer for quantum mutual information.
- [08-04] L. Kampmeijer, J.K. Slingerland, B.J. Schroers & F.A. Bais: Magnetic charge lattices, moduli spaces and fusion rules.
- [08-05] E. Akofer, A.P. Balachandran, A. Joseph, B.A. Qureshi & L. Pekowsky: Constraints from CMB on spacetime noncommutativity and causality violation.
- [08-06] G. Kells, A.T. Bolukbasi, V. Lahtinen, J. Slingerland, J.K. Pachos & J. Vala: Topological degeneracy and vortex dynamics in the Kitaev honeycomb model.
- [08-07] T.C. Dorlas & E.G.F. Thomas: The discrete Feynman integral.
- [08-08] O.J. Rosten: Constraints on an asymptotic safety scenario for the Wess-Zumino model.
- [08-09] O.J. Rosten: Triviality from the exact renormalization group.
- [08-10] F.A. Bais & J.K. Slingerland: Condensate induced transitions between topologically ordered phases.
- [08-11] O.J. Rosten: On the Renormalization of theories of a scalar chiral superfield.
- [08-12] C. Nash & Denjoe O'Connor: Topological phase transition and holonomies in the dimer model.
- [08-13] G.K. Brennen, S. Iblisdir, J.K. Pachos & J.K. Slingerland: Non-locality of non-Abelian anyons.
- [08-14] L. Kampmeijer, S. Bais, B. Schroers & J. Slingerland: Towards a non-Abelian electric-magnetic symmetry: the skeleton group.
- [08-15] R. Blumenhagen, V. Braun, T. Grimm & T. Weigand: GUTs in Type IIB orientifold compactifications.
- [08-16] T.C. Dorlas, A.M. Povolotsky & V.B. Priezzhev: From vicious walkers to TASEP
- [08-17] T. Dorlas & C. Morgan: The classical capacity of quantum channels with memory.
- [08-18] C. Nash & Denjoe O'Connor: The zero temperature phase diagram of the Kitaev model.
- [08-19] V. Dotsenko: Compatible associative products and trees.
- [08-20] V. Dotsenko: Parking functions and vertex operators.
- [08-21] F.A. Bais, J.K. Slingerland & S.M. Haaker: A theory of topological edges and domain walls.
- [08-22] V.G. Filev: Aspects of the holographic study of flavor dynamics.
- [08-23] M. Leitner & W. Nahm: Boundary states and edge currents for free fermions.
- [08-24] R. Delgadillo-Blando, D. O'Connor & B. Ydri: Matrix models, gauge theory and emergent geometry.
- [08-25] Denjoe O'Connor, J.A. Santiago & C.R. Stephens: An ab initio calculation of the universal equation of state for the $O(N)$ Model.

3 Programme of Scholarly Events

3.1 Lectures Organised by The School

- V. Braun (Pennsylvania, USA) *Calabi-Yau metrics and the spectrum of the Laplacian*. 14 February
- S. Kovacs (Dublin) *Instantons and holography*. 14 February
- G. Policastro (Paris) *Gauge theories and strings*. 14 February
- D. Roest (Barcelona) *Kac-Moody symmetries in supergravity*. 14 February

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3.1.1 Seminars Organised by The Theoretical Particle Physics Group

- E. Ardonne (Nordita) *Non-Abelian quantum Hall states in the thin torus limit*. 28 February
- P. Bonderson (Microsoft Research Station Q) *Measurement – only topological quantum computation*. 21 August
- N. Boulanger (Scuola Normale Superiore, Italy) *General solutions of the Wess-Zumino consistency condition for the Weyl anomalies*. 27 March
- M. Christandl (Lehrstuhl für theoretische Festkörperphysik, Munich) *Post-selection technique for permutation-invariant quantum channels*. 18 September
- P. Fendley (University of Virginia, Charlottesville/Oxford) *Topological entanglement entropy from the holographic partition function*. 22 May
- J. Gaiete (Instituto de Microgravedad, Univ. Politecnica de Madrid) *Scaling laws in the cosmic structure and renormalization group*. 7 February
- J.P. Gazeau (Paris 7) *Fuzzy de Sitter space-times via coherent states quantization*. 22 February
- T.R. Govindarajan (Institute of Mathematical Sciences Chennai, India) *Towards standard model in Moyal space time*. 12 June
- W. Greenberg (University of Maryland) *Systematic method to solve operator quantum field theories*. 29 July
- K. Gupta (Saha Institute of Nuclear Physics, Kolkata, India) *Holography and quasi-normal modes of black holes*. 29 May
- S. Kurkcuoglu (Institut für Theoretische Physik, Leibniz Universität Hannover) *Noncommutative nonlinear systems and integrability*. 3 July
- J. Lucietti (Durham) *Black hole near-horizon geometries*. 17 April
- V.S. Malinovsky (MagiQ Technologies, Inc., New York) *Collapse and revival of entanglement of two interacting qubits*. 4 November

- N. Regnault (Ecole Normale Supérieure, France) *Multi-component fractional quantum Hall effect*. 26 March
- J. Shock (IGFAE Spain) *Holographic spectral functions at finite Baryon density*. 20 November
- P. Schupp (Jacobs University Bremen) *Noncommutative gravity and fuzzy Schwarzschild solution*. 5 June
- V. Tarasov (Steklov Institute of Mathematics, Indiana University-Purdue University Indianapolis) *Bethe ansatz and Schubert calculus*. 24 June
- S. Trebst (Microsoft Research) *Collective states of interacting anyons: things golden*. 15 May
- C. Young (Durham) *Identical particles in kappa-deformed quantum field theory*. 8 May

3.2 Symposia, Conferences, Workshops Organised

An EU-NCG Mini-Workshop on Fuzzy Physics and Random Matrices was held from 28th January until 1st February. The following lectures were delivered with discussions and follow ups in the afternoons.

- S. Doplicher (Universite Roma) *Quantum spacetime and quantum field theory-I*.
- H. Grosse (University of Vienna) *Progress in NCQFT: I. Euclidean formulation: gauge models and fermions*.
- P. Presnajder (Comenius University, Bratislava, Slovakia) *The fuzzy sphere – an introduction to fuzzy-matrix models*.
- A. Guionnet (U.M.P.A., Ecole Normale Supérieure de Lyon) *Topological expansion–matrix integrals as generating functions for the enumeration of maps*.
- R. Wulkenhaar (Universität Münster) *Renormalisation of ϕ_4^4 on Moyal space with oscillator potential*.
- A. Guionnet (U.M.P.A., Ecole Normale Supérieure de Lyon) *Itzykson-Zuber Harish-Chandra integrals*.
- H. Grosse (University of Vienna) *Progress in NCQFT: II. Wedge locality in Minkowski spacetime*.

- B. Dolan (NUI Maynooth) *A universal Dirac operator and non-commutative spin bundles over fuzzy CP^n .*
- S. Doplicher (Universite Roma) *Quantum spacetime and quantum field theory-II.*
- P. Presnajder (Comenius University, Bratislava, Slovakia) *Fuzzy twistors.*
- C. Sämann (Trinity College Dublin) *Constructing noncommutative projective algebraic varieties.*
- O. Rosten *Wilsonian renormalization of the Grosse & Wulkenhaar model.*
- R. Wulkenhaar (Universitat Muenster) *A spectral for 4D-Moyal space.*
- S. Bal *The instability of intersecting fuzzy spheres.*

The fourth in the series of **John Lewis Lectures** were delivered by Professor Jennifer Tour Chayes (Microsoft, Redmond, Washington). The lecture series is jointly organised by the Dublin Institute for Advanced Studies and the Hamilton Mathematics Institute at Trinity College Dublin with generous donation from Raymond Russell and Corvil Networks. The following lectures were delivered:

- *Models of the internet and the world wide web.* 26 February
- *Mathematical behaviour of random scale-invariant networks.* 27 February

A supplementary lecture was delivered by Professor K.R. Sreenivasan (ICTP, Trieste). The lecture entitled *Cryogenic turbulence* was delivered on 23 April.

OGAM in 3D a one day conference organised jointly by the School of Theoretical Physics and the School of Celtic Studies was held on Saturday 24 May. The following lectures were delivered.

- W. Nahm *Introduction to the Ogam in 3D Conference.*
- A. Tokovine (Harvard University) *Saving and studying Maya monuments in the 21st century.*
- C. Muir (Historic Scotland's Conservation Centre, Edinburgh) *The scanning of Scotland's stones.*

- A. la Pensée (National Museums Liverpool) *3D laser scanning of outdoor stone.*
- D. Ó Cróinín & T. Daubos (NUI Galway) *The Irish inscribed stones project in Galway: the experience of 3D laser imaging of inscribed stone monuments from early medieval Ireland.*
- F. Moore (Department of the Environment, Dublin) *The Ogam inscriptions and sites.*

The First Annual Meeting of the EU Network in Noncommutative Geometry was held from 16-20th June.

The following lectures were delivered.

- D. Voiculescu (University College Berkeley) *Aspects of free analysis: the analogue of the Riemann sphere.*
- D. Buchholz (University of Göttingen) *The resolvent algebra: A new approach to canonical quantum systems.*
- B. Dolan (NUI Maynooth) *A universal Dirac operator and spin^c bundles over fuzzy CP^n .*
- D. Evans (Cardiff University) *Modular invariants and twisted K-theory.*
- R. Gohm (Aberystwyth University) *Noncommutative independence from Braid group representations.*
- R. Nest (Copenhagen University) *Universal coefficient theorems for Kirchberg's KK-theory.*
- P. Martinetti (University of Göttingen) *The standard model from the metric point of view.*
- R. Longo (University of Rome, Tor Vergata) *SUSY in the conformal world.*
- E. Ortega (University of Southern Denmark) *The maximal C^* -algebra of quotients as an operator bimodule.*
- C. Sämann (Trinity College Dublin) *Generalized Berezin Quantization, Bergman metrics and fuzzy Laplacians.*
- M. Izumi (Kyoto University) *Group actions on Kirchberg algebras.*

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- H. Grosse (University of Vienna) *Renormalizable noncommutative quantum field theory.*
- N.S. Larsen (University of Oslo) *Phase transition in the Bost-Connes C^* dynamical systems from number fields.*
- F. Radulescu (University of Rome, Tor Vergata) *Typell, Von Neumann representations for Hecke operators on Maass forms and inequalities for their eigenvalues.*
- A. Knebusch (University of Göttingen) *Approximation of center-valued Bettinnumbers.*
- G. Lechner (University of Vienna) *Noncommutative deformations of quantum field theories.*
- B. Qureshi *Twisted symmetries in quantum field theory.*
- A.P. Balachandran (Syracuse University) *Causality on the Moyal plane.*
- E. Beggs (Swansea University) *Non-commutative complex structures, sheaf theory and characteristic classes.*
- F. Boca (Institute of Mathematics, Bucharest) *Continued fractions and operator algebras.*
- S. Brain (SISSA, Trieste) *Twistor construction of noncommutative instantons.*
- H. Bostelmann (University of Rome, Tor Vergata) *A local approach to quantum inequalities.*
- P. Schupp (Jacobs University, Bremen) *Exact solutions in noncommutative gravity.*
- C. Lazaroiu (Trinity College Dublin) *The affine noncommutative geometry of Calabi-Yau spaces.*
- R. Conti (University of Newcastle, NSW) *Localized automorphisms of the Cuntz algebras.*
- T. Gannon (University of Alberta, Canada) *Galois actions on finite groups.*
- E. Germain (Université de Caen Basse-Normandie) *Folner sequences and group C^* -algebras.*

The Sixth Symposium on Topological Quantum Computation was held from 15-17 September. The following lectures were delivered.

- M. Leitner *Boundary states and edge currents for free fermions.*
- A. Bölükbaşı (NUI Maynooth) *Vortices in Kitaev's honeycomb model.*
- G. Misguich (CEA-Scalay) *Topological order in Mott insulators and dimer models.*
- O. Buerschaper (MPI Garching) *Tensor networks and topological phases.*
- Z. Wang (MS Station Q) *Topological properties of Abelian and non-Abelian quantum Hall states from the pattern of zeros.*
- N. Regnault (LPA, CNRS) *A colorful approach to the fractional quantum Hall effect.*
- J. Wootton (University of Leeds) *Emergence of non-Abelian statistics from an Abelian model.*
- B. Douçot (LPTHE, CNRS) *Physical implementation of protected qubits.*
- K. Schoutens (Univ. of Amsterdam) *Non-Abelian anyons: when Ising meets Fibonacci.*
- G. Möller (Cambridge) *Quantum Hall effect of bosons in optical lattices.*
- V. Lahtinen (University of Leeds) *Braid statistics as a holonomy in Kitaev's honeycomb lattice model.*

A Workshop on Mathematical Aspects of Transport in Mesoscopic Systems was held from 4-7 December. The following talks were delivered.

- C.A. Pillet (Marseille) *Spectral analysis of a CP map and thermal relaxation of a QED cavity.*
- F. Mehats (Rennes) *Effective mass approximation for a bidimensional electron gas in a strong magnetic field.*
- R. Purice (Bucarest) *NESS as adiabatic limit on the potential bias.*

- P. Exner (Prague) *Approximation of nontrivial quantum graphs by Schrödinger operators on Neumann networks.*
- T. Pedersen (Aalborg) *Linear and nonlinear optical properties of carbon nanotubes.*
- H. Neidhardt (Berlin) *Kohn-Sham systems at zero temperature.*
- H. Cornean (Aalborg) *Trions and biexcitons in quasi one-dimensional systems.*
- F. Peeters (Anvers) *Graphene superlattices.*
- R. Ben Saad (Tunis) *Mourre approach to the Landaeur-Buttiker formalism.*
- V. Falko (Lancaster) *Quantum transport in disordered graphene structures.*
- P. Racec (Berlin) *Modeling of quantum transport in cylindrical nanowire heterostructures.*
- T. Dorlas *Quantum information and computing.*
- V.A. Zagrebnov (Marseille) *Mean-field interacting boson random point processes in weak traps.*

A Workshop on Integrable Quantum Systems was held from 8-12 December. The following talks were delivered.

- W. Nahm *The energy spectrum of integrable systems.*
- T. McLoughlin (Max-Planck Institute, Golm) *Quantum strings in $AdS_4 \times P^3$.*
- A. Klümper (University of Wuppertal) *Methods and scope of investigations of integrable quantum systems at finite temperature.*
- F. Göhmann (University of Wuppertal) *Temperature correlators of the XXZ chain.*
- R. Suzuki (Trinity College Dublin) *Generalized Lüscher formula and finite-size effects of AdS/CFT.*
- S. Frolov (Trinity College Dublin) *Strings in $AdS_4 \times P^3$ as a coset sigma model.*

- E. Ragoucy (Laboratoire d'Annecy-le-Vieux de Physique des Particules) *Universal Hubbard models and AdS/CFT.*
- F. Spill (Imperial College London) *The asymptotic S-matrix of AdS/CFT.*
- C. Young (Durham University) *Magnons and Boundaries*

Statutory Public Lecture.

The Statutory Public Lecture delivered by Professor Rolf-Dieter Heuer, the incoming director-general of Cern, was hosted by University College Dublin and was held in the RDS Concert Hall on 24 November. The title was *The large Hadron collider shedding light on the dark universe.*

4 Presentations at Conferences or Seminars

4.1 Talks and Papers Presented

T.C. Dorlas:

- Invited talk "Thermodynamic limit of the six-vertex model" at "Conference on Statistical Mechanics" Rutgers University, USA, 11-13 May.
- Colloquium talk "The discrete Feynman integral" Centre de Physique Théorique, Marseille, 10 June.
- Invited talk "Rigorous Bethe Ansatz" at workshop "Analysis and Stochastics in Quantum Many-Body Systems" Oberwolfach, 17-19 September.
- Talk "Hierarchical Bosons" at workshop "Quantum Many-Body Systems: Bose-Einstein Condensation" at Centre de Recherches Mathématiques (CRM), Montréal, Canada, 3 October.

W. Nahm:

- Invited talk "Quantum groups, modular forms and integrable quantum field theories" at "Symmetries in Mathematics and Physics", Cortona, Italy, 23 June.
- Invited talk "Yangian characters and modular forms" at "XXVII International Colloquium on Group Theoretical Methods in Physics", Yerevan, Armenia, 13 August.

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Denjoe O'Connor:

- Talk "Geometry in transition: A model of emergent geometry", ICN, UNAM, Mexico 3 April.
- Talk "Geometry in transition", Mathematical Physics Colloquium, Wales Institute of Mathematical and Computational Sciences, Cardiff University, 6 November.
- Talk "Geometry in Transition", Workshop in Memoriam Julius Wess, Vienna, 5 December.

V. Braun:

- Talk "Heterotic string model building" at workshop "Mathematical Challenges in String Phenomenology" at Erwin Schrödinger Institute for Mathematical Physics, Vienna, 6-15 October.
- Seminar "Calabi-Yau metrics and the spectrum of the Laplacian" at workshop "Mathematical Challenges in String Phenomenology" at Erwin Schrödinger Institute for Mathematical Physics, Vienna, 6-15 October.

F.A.H. Dolan:

- Talk "Applications of the superconformal index for protected operators and q-hypergeometric identities to $N=1$ dual theories" was delivered at the following institutes/universities: University of Durham, 18 January; University of Southampton, 25 January; Imperial College London, 6 February; Scuola Normale Superiore di Pisa, 10 April; University of Amsterdam, 20 May.

V. Dotsenko:

- Seminar "Compatible associative products and trees" Swiss Federal University of Technology Zürich (ETH Zürich), 23 October.

V. Filev:

- Seminar "Holographic study of flavoured $N=4$ Yang-Mills in external magnetic field", Southampton University, 21 October.
- Talk "Holographic chiral dynamics", University of Southern California, 8 December.

A. Ghesquire:

- Poster presentation "Study of the Entanglement of a Gaussian two-particle system" at "QICS Workshop on Foundational Structures for Quantum Information and Computation" Obergurgl, Tyrol, Austria, 14-20 September.
- Poster presentation "Study of the Entanglement of a Gaussian two-particle system" at "Workshop on Mathematical Aspects of Transport in Mesoscopic Systems" Dublin Institute for Advanced Studies, 4-7 December.

M. Leitner:

- "Graphene and its Symmetries" at "27th International Colloquium on Group Theoretical Methods in Physics" Yerevan (Armenia), 11-18 August.

C. Morgan:

- Poster presentation "The classical capacity of a periodic quantum channel" at "QICS Workshop on Foundational Structures for Quantum Information and Computation" Obergurgl, Tyrol, Austria, 14-20 September.

A. Povolotsky:

- Talk "From vicious walkers to TASEP" at conference "RG2008" Dubna, Russia, 1-6 September.

B. Qureshi:

- Talk "Noncommutative gauge theories" at "Fifteenth Irish Quantum Field Theory Meeting (IQFT 2008)", NUIM, Maynooth, 17 May.
- Talk "Twisted Poincaré symmetry and noncommutative quantum field theory" at "First Annual Meeting of European Union Noncommutative Geometry Network (EU-NCG)", DIAS, 20 June.
- Talk "Noncommutative black holes" at Black Hole Theory Institute of CERN Theoretical Division, CERN, Geneva, Switzerland, 25 September.

O. Rosten:

- Talk "Invariants of the exact renormalization group" at "ERG 2008" conference, Heidelberg, 1-5 July.

J. Slingerland:

- Seminar "Fractional quantum Hall hierarchy and the second Landau level" at Edinburgh Mathematical Physics Group seminar, Edinburgh University and Heriot-Watt University, Edinburgh, 22-25 January.
- Talk "Topological quantum computation" at International Workshop on "The Mathematical Foundations of Quantum Control and Quantum Information Theory, QCI2008", Madrid, 26-30 May.
- Talk "Fractional quantum Hall trial wave functions" at KTH/Nordita/SU seminar in theoretical physics, Nordita, Stockholm, 31 May – 8 June.
- Talk "Condensation induced transitions between topological phases" at workshop "Quantum Computation with Topological Phases of Matter", Banff International Research Station, Banff, Canada, 20-25 July.
- Talk "Condensate induced transitions between topological phases" at Nordita conference on "Conformal field theory approach to quantum Hall physics-non-Abelian statistics and quantum computing" Nordita, Stockholm, 13-16 August.

5 Collaboration with the Wider Research Community

5.1 National

Lecture Courses and Workshops

W. Nahm:

- Delivered a series of ten lectures on *Conformal Field Theory and All That*.
- Organized the HMI Workshop on "Gauge Theories, Moduli Spaces and Representation Theory", April.

Denjoe O'Connor:

- Organised the Workshop on "Fuzzy Physics and Noncommutative Geometry", DIAS, 5-16 June.

V. Dotsenko:

- Course for undergraduates on *Linear Algebra* (Academic Year 2008-2009)

J. Slingerland:

- Organized the "Sixth Symposium on Topological Quantum Computation", Dublin Institute for Advanced Studies, 15-17 September.

Visiting Researchers from Irish Universities

- B. Dolan was on sabbatical from NUI Maynooth from September to the end of December.

Staff Acting as External Supervisors

Denjoe O'Connor:

- Ph.D. supervisor for Rodrigo Delgadillo Blando (Cinvestav, Mexico)
- Ph.D supervisor for Fernando Garcia Flores (Cinvestav, Mexico)
- Ph.D. supervisor for Idrish Huet Hernandez (Cinvestav, Mexico)
- Ph.D. Supervisor for Séan Murry, NUIM, Maynooth, Ireland.

Staff Acting as External Examiners

W. Nahm:

- External examiner for the Department of Physics and the Department of Mathematics in Trinity College Dublin.

J. Slingerland:

- The adjudication of an M.Sc. Thesis entitled "Discrete gauge theories in two spatial dimensions: A Euclidean lattice approach" by J.C. Romers, under supervision of Prof. F.A. Bais, Institute for Theoretical Physics, University of Amsterdam, Amsterdam, 23-26 February.

Speakers Sponsored at Outside Conferences/ Meetings

- The School sponsored H. Saleur (University of Southern California, Los Angeles and Saclay) who delivered the Annual O'Raifeartaigh Lecture as part of the Fifteenth Irish Quantum Field Theory Meeting at NUI Maynooth 16-17 May. J. Conlon (DAMTP, Cambridge), N. Dorey (DAMTP, Cambridge) and M. Mueller-Preussker (Humboldt University, Berlin) were also sponsored.

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Research Associates

- AT&T: N. Duffield
- DCU: E. Buffet, J. Burzlaff, E. O’Riordan
- DIT: T. Garavaglia, D. Gilbert, M. Golden, B. Goldsmith, P. Houston, E. Prodanov
- INTERN. CENTRE FOR THEORETICAL PHYSICS, TRIESTE : J. Chela-Flores
- IT, CARLOW: D. O Sé
- IT, TALLAGHT: N. Gorman
- LUDWIG-MAXIMILIANS UNIVERSITÄT MÜNCHEN: I. Sachs
- METEOROLOGICAL SERVICE: P. Lynch
- NUI, CORK: N. O’Connell, M. Vandyck
- NUI, GALWAY: J. Burns, M.J. Conneely, M.P. Tuite
- NUI, MAYNOOTH: M. Daly, B. Dolan, D. Heffernan, C. Nash, A. O’Farrell, J.A. Slevin, D.H. Tchrakian
- OPEN UNIVERSITY: A.I. Solomon
- OXFORD UNIVERSITY: R.G. Flood
- TCD: P.S. Florides, J. Miller, D. Weaire
- UNIVERSITEIT LEIDEN: F. Freire
- UCD: A. Ottewill, J.V. Pulé, W. Sullivan, P. Watts
- UL: S. O’Brien
- UNAFFILIATED: G.M. O’Brien, D. Ó Mathúna

5.2 International

W. Nahm:

- Member of the evaluation committee for the IMPRS (International Max Planck Research School) at Leipzig, September.
- Evaluated a research proposal for The Foundation for Fundamental Research on Matter (FOM), Netherlands.
- Evaluated the application of Humboldt University Berlin for continuing support of SFB 647 “Space-Time-Matter: Analytical and Geometrical Structures” for the German Research Society, July.
- Evaluated the candidates for a tenured associate professorship in mathematical physics at Hamburg University.

Denjoe O’Connor:

- Member of International Advisory board of the Central European Joint Programme of Doctoral Studies in Theoretical Physics (<http://umbriel.phy.hr/cejp/>).

A. Povolotsky:

- An ongoing collaboration with the group of V.B. Priezzhev, Dubna, Russia.

B. Qureshi:

- Reviewed research grant proposals for National Science Foundation (NSF).

M. Samsonov:

- A collaboration with Prof. P.P. Kulish of the branch of the Steklov Mathematical Institute in St. Petersburg and Prof. A. A. Stolin of Chalmers University of Technology and Göteborg University on “The deformed Gaudin model and the Bethe – Ansatz for it”.

Lecture Courses and Workshops

J. Slingerland

- Lecture course on “Topological Quantum Computation”, CoQuS Summer School, University of Vienna, Austria, 8-12 September.

Visiting Researchers

Short visits (up to one week):

- W. Bietenholz (University Regensburg/DESY Zeuthen) 8-13 December
- V. Braun (University of Pennsylvania) 24-28 August
- S. Kurkcuglu (University of Hannover) 30 June – 6 July
- J. Medina Garcia (Polytechnic Institute, Mexico) 7-14 December
- J. Shock (University of Santiago de Compostela, Spain) 18-21 November
- K.R. Sreenivasan (ICTP, Trieste) 22-24 April

Long visits:

- R. Delgadillo Blando (Mexico) 7-22 December
- P. Bonderson (Microsoft Station Q, Santa Barbara) 18-27 August
- P. Duclos (Centre de Physique Théorique, Marseille) 21-29 August, 4-7 December

- G.W. Ford (Michigan University, Ann Arbor) 13-30 June
- Jose Antonio Santiago Garcia (Centro de Investigacion en Matematicas, UAEH, Mexico) 7-19 July
- K.S. Gupta (SINP, Kolkata, India) 15 April – 15 June
- P. Kulish (Steklov Math. Institute, St. Petersburg, Russia) 3-26 November
- R.F. O’Connell (Louisiana State Univ., Baton Rouge) 26 May – 28 July
- V.B. Priezzhev (Joint Inst. for Nuclear Research (JINR), Dubna, Russia) 12-22 November
- Pedro A. Miranda Romagnoli (Centro de Investigacion en Matematicas, UAEH, Mexico) 7-19 July
- A. Stolin (University of Gothenburg, Sweden) 16 October – 14 November
- V. Tarasov (St. Petersburg, Russia) 10-25 June
- B. Ydri (Humboldt-Universitat Zu Berlin) 1 June – 8 July

Research Visits by School Staff

T.C. Dorlas:

- Research visits to Centre de Physique Théorique in Marseille for research collaboration with Profs. P. Duclos, J. V. Pulé, and V. A. Zagrebnov on the Ulysses project “A mathematical analysis of quasi-particles and transport in carbon nanotubes II”, 2-12 July, 8-12 October. (The latter also in order to facilitate the organisation of a conference, to be held at DIAS in December.)
- Research visit to the Joint Institute of Nuclear Research, Dubna (Russia), 10-20 August.

Denjoe O’Connor:

- Research visit to Mexico, 7 March – 4 April.
- Research visit to Berlin, 21-25 April.
- Research visit to University of Tours, France, 16-27 July.

S. Bal:

- Research visit to Queen Mark College, University of London, 15-25 July.

V. Braun:

- Research visit to the University of Pennsylvania, Philadelphia 29 October – 5 November.
- Research visit to Imperial College London, 3-12 December.

V. Dotsenko:

- Research visit to Swiss Federal University of Technology Zürich (ETH Zürich), 22-24 October

V. Filev:

- Research visit to Southampton University, 20-23 October.
- Research visit to University of Southern California, 8-9 December.

C. Morgan:

- Research visit to the Quantum Computation and Information Group, University of Bristol, 12-14 June.

A. Povolotsky:

- Visit to JINR, Dubna, Russia, July-August.
- Research visit to University of Lisbon, Portugal, 30 September – 2 October.

B. Qureshi:

- Visit to Black Holes Theory Institute of CERN Theoretical Division, Geneva, Switzerland, September – October.

O. Rosten:

- Research visit to the Perimeter Institute, Waterloo, Canada 14 April – 9 May.

M. Samsonov:

- Research visit to Steklov Mathematical Institute, St. Petersburg, Russia, 24 August – 3 October.

J. Slingerland:

- Visit to the Institute for Theoretical Physics, University of Amsterdam, Amsterdam, The Netherlands, 17-18 January, 23-26 February, 6-7 November, 17-18 December.
- Visit to Heriot-Watt University including EMPG-seminar “Fractional quantum Hall hierarchy and the second Landau level”, Edinburgh, 22-25 January.
- Visit to Nordita, including KTH/Nordita/SU seminar in theoretical physics, Stockholm, 31 May – 8 June.

- Visit to Microsoft Station Q, including participation in the Microsoft Summer Meeting, UC Santa Barbara, 25 June – 5 July.
- Visit to University of California Riverside, 7-8 July.
- Visit to Microsoft Station Q, including participation in the Microsoft Fall Meeting, UC Santa Barbara, 8-15 December.

6 Participation in Outside Committees

W. Nahm:

- Member of the selection committee for the position of Lecturer in Theoretical Physics at TCD.
- Reviewed an application of a TCD lecturer for promotion to Senior Lecturer.
- Member of the RIA Committee for Mathematical Sciences.

7 Attendance at External Conferences, Workshops, Meetings and Lectures

7.1 Conferences/ Workshops/ Scientific Meetings Attended

W. Nahm:

- Conference to honour the 65th birthday of Victor G. Kac (MIT), Palazzone della Scuola Normale Superiore, Cortona, Italy, 22-25 June.
- XXVII International Colloquium "Group Theoretical Methods in Physics", Yerevan, Armenia, 11-18 August.

T.C. Dorlas:

- 99th Statistical Mechanics Conference, Rutgers University, New Jersey, 11-13 May.
- Workshop "Analysis and Stochastics in Quantum Many-Body Systems" Oberwolfach (Germany), 31 August – 6 September.
- Workshop "Quantum Many-Body Systems; Bose-Einstein Condensation" Centre de Recherches Mathématiques (CRM), Montréal, Canada, 29 September – 4 October.

- Workshop "Mathematical Aspects of Transport in Mesoscopic Systems" DIAS, 4-7 December.
- 100th Statistical Mechanics Conference, Rutgers University, New Jersey, 13-18 December.

Denjoe O'Connor:

- "The 1st Annual Meeting of the EU Network in Noncommutative Geometry" DIAS, 16-20 June.
- Workshop "Fuzzy Physics and Non-commutative Geometry" DIAS, 20-25 June.
- Mathematical Physics Colloquium, Cardiff University, 5-8 November.
- "Julius Wess Memorial Conference" Vienna, 3-5 December.

V. Braun:

- Workshop "Mathematical Challenges in String Phenomenology", Erwin Schrödinger Institute for Mathematical Physics, Vienna, 5-15 October.

F.A.H. Dolan:

- Annual Theory Meeting, Durham, 17-19 December.

V. Dotsenko:

- Workshop "Higher Structures 2008" Swiss Federal University of Technology Lausanne (EPFL Lausanne), 3-7 November.

V. Filev

- Southern California String Seminar, University of Southern California, Los Angeles, 8-9 December.

A. Ghesquire:

- "QICS Workshop on Foundational Structures for Quantum Information and Computation", Obergurgl, Austria, 14-20 September.
- "Workshop on Mathematical Aspects of Transport in Mesoscopic Systems", DIAS, 4-7 December.

M. Leitner

- "Irish Geometry Conference" Tralee, 12-13 May.

- "XXVII International Colloquium on Group Theoretical Methods in Physics" Yerevan (Armenia), 11-18 August.

C. Morgan:

- "International Workshop on the Mathematical Foundations of Quantum Control and Quantum Information Theory", Fundación Ramón Areces, Madrid, 26-30 May.
- "QICS Workshop on Foundational Structures for Quantum Information and Computation", Obergurgl, Austria, 14-20 September.

A. Povolotsky:

- Conference "Renormalization Group and Related Topics 2008" JINR, Dubna, Russia, 1-6 September.

B. Qureshi:

- Workshop "Fuzzy Physics and Random Matrices" DIAS, 28 January-2 February.
- Workshop "Gauge Theories, Moduli Spaces and Representation Theory" Hamilton Mathematics Institute, Dublin, 7-12 April.
- "First Annual Meeting of European Noncommutative Geometry Network" DIAS, 16-20 June.
- Conference "Quantum Spacetime and Non-commutative Geometry" University of Rome, 29 September – 4 October.
- Workshop "Integrable Quantum Systems" DIAS, 8-12 December.

O. Rosten:

- "ERG 2008" Heidelberg, 1-5 July.

M. Samsonov:

- "MP2 Summer School 2008 on Algebraic and Computational Methods for Strongly Correlated Systems" Göteborg, Sweden, 18-23 August.

J. Slingerland:

- Edinburgh Mathematical Physics Group Seminar, Edinburgh University and Heriot-Watt University, Edinburgh, 22-25 January.
- 5th Symposium on "Topological Quantum Information", University of Leeds, 13-14 April.

- International Workshop on "The Mathematical Foundations of Quantum Control and Quantum Information Theory, QCI2008" Madrid, 26-30 May.
- KTH/Nordita/SU Seminar in Theoretical Physics, Nordita, Stockholm, 31 May – 8 June.
- Microsoft Summer Meeting, Microsoft Station Q University of California Santa Barbara, 27-29 June.
- Workshop "Quantum Computation with Topological Phases of Matter", Banff International Research Station, Banff, Canada, 20-25 July.
- Nordita conference on "Conformal Field Theory Approach to Quantum Hall Physics – non-Abelian Statistics and Quantum Computing" Nordita, Stockholm, 13-16 August.
- Microsoft Fall Meeting, Microsoft Station Q, University of California Santa Barbara, 12-14 December.

7.2 Lectures and Organisational Meetings Attended

T.C. Dorlas:

- "The Mathematics of Dynamic Random Networks". 1. "Models of the Internet and the World Wide Web". 2. "Mathematical Behaviour of Random Scale-Invariant Networks", the fourth series of Distinguished John Lewis Lectures given by Professor Jennifer Tour Chayes, Microsoft (Redmond, Washington), 26-27 February.
- "Cryogenic Turbulence" by K.R. Sreenivasan (ICTP, Trieste) 23 April 2008. John Lewis Lecture Series organised jointly by HMI & DIAS, 23 April.
- "The Large Hadron Collider Shedding Light on the Dark Universe" Statutory Public Lecture by Professor Rolf-Dieter Heuer, incoming director-general of CERN, RDS, 24 November.

8 Research Grants/External Funds Secured

W. Nahm:

- A grant of €18,900 for co-ordination support concerning an FP7 proposal (Marie Curie INT on Topological Quantum Computing) from Enterprise Ireland.

T.C. Dorlas:

- Small subvention (€2,000) from the French Embassy in Dublin, and also a contribution of €1,000 from the Centre de Physique Théorique in Marseille towards the organisation of a workshop on "Mathematical aspects of transport in mesoscopic systems", DIAS, 4-7 December.

Denjoe O'Connor:

- 2007-2011: Node of Marie Curie Research Training Network €233,652.73.
- 2006-2008: An Embark Initiative Postdoctoral Fellowship to Oliver Rosten funded by IRCSET for a period of two years years with effect from 1 October 2006.
- 2006-2008: An Embark Initiative Postdoctoral Fellowship to Frances Dolan funded by IRCSET for a period of two years years with effect from 1 October 2006.
- 2007-2009: An Embark Initiative Postdoctoral Fellowship to Babar Qureshi funded by IRCSET for a period of two years years with effect from 1 December 2007.
- 2008-2010: An Embark Initiative Postdoctoral Fellowship to Veselin Filev funded by IRCSET for a period of two years years with effect from 1 October 2008.
- 2008-2010: An Embark Initiative Postdoctoral Fellowship to Vladimir Dotsenko funded by IRCSET for a period of two years years with effect from 1 October 2008.

J. Slingerland:

- Science Foundation of Ireland Principal Investigator grant.

Proposal Title: Topological Order, Quantum Computation and the Fractional Quantum Hall Effect
Reference Number: 08/IN.1/I1961

Principal Investigator: Dr. Johannes Slingerland
Staff funded: 1 postdoctoral fellow (3 years),
2 graduate students (each 3 years).

Approved Programme Budget (Direct Costs):
€379,565 Term: 48 Months.

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